Energy Peace Partners

Renewable energy and peace: Empirical analysis of global data

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Key Findings

- There is a positive and statistically significant correlation between access to electricity and peace (both negative peace and positive peace).

- There is a positive and statistically significant correlation between non-hydro renewable energy generation and peace (both negative peace and positive peace).

- Non-hydro renewable energy generation has the potential to increase levels of sustainable peace in the 'triple-threat' nexus of countries - that is countries that have low rates of electrification, are climate vulnerable and conflict affected. A higher share of non-hydro renewable energy generation affects future levels of positive peace - that is, it can help build sustainable peace in the medium to long term. If a country were to move theoretically from 0 percent to 100 percent non-hydro renewable energy generation, this could increase the level of sustainable peace by as much as 12 percent.

- Higher levels of electricity *access* (renewable or non-renewable) decreases future levels of conflict in the triple-threat countries, but the share of renewable energy *consumption* has no effect on future levels of conflict or peace.

Acronyms

EPP	Energy Peace Partners
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GPI	Global Peace Index
GW	Giga Watt
IEP	Institute for Economics and Peace
KwH	Kilo Watt Hour
MW	Mega Watt
PPI	Positive Peace Index
RE	Renewable Energy
SDG	Sustainable Development Goal
UN	United Nations
WB	World Bank
WDI	World Development Indicators

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1. Introduction

The importance of energy access and electrification globally is enshrined in Sustainable Development Goal 7 which calls for a global commitment to action to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030. The goal encompasses three dimensions: universal access to energy, a higher share of renewable energy, and an improvement in energy efficiency. Beyond just this goal, however, energy access ties into almost all the other Sustainable Development Goals by facilitating and enabling relevant development goals. Renewable energy in particular has been called out for its central importance to achieving many of the other SDGs, including SDG 16: Peace, Justice and Strong Institutions.[1]

Yet roughly 10 percent of the world's population - 800 million people - are still without access to electricity, 90% of whom live in fragile states.[2] The energy and power sectors in fragile countries remain underdeveloped. By one estimate, the 48 countries making up sub-Saharan Africa with a total population of over 1.1 billion, had a power generation capacity of 103 GW; at the same time, Spain, with a population of 47 million, could generate 106 GW. This capacity is insufficient to meet demand; to meet the energy demand level in 2040 in sub- Saharan Africa, the region will need to build 300 GW of additional capacity. This comes at a price-tag of more than $490 billion. To meet SDG 7 would require tripling the number of people gaining access to electricity every year from 20 to 60 million.[3]

And in many instances, where some energy access exists, the quality and reliability is very low, leading to frequent power shortages and outages, and affecting economic growth and human development[4].

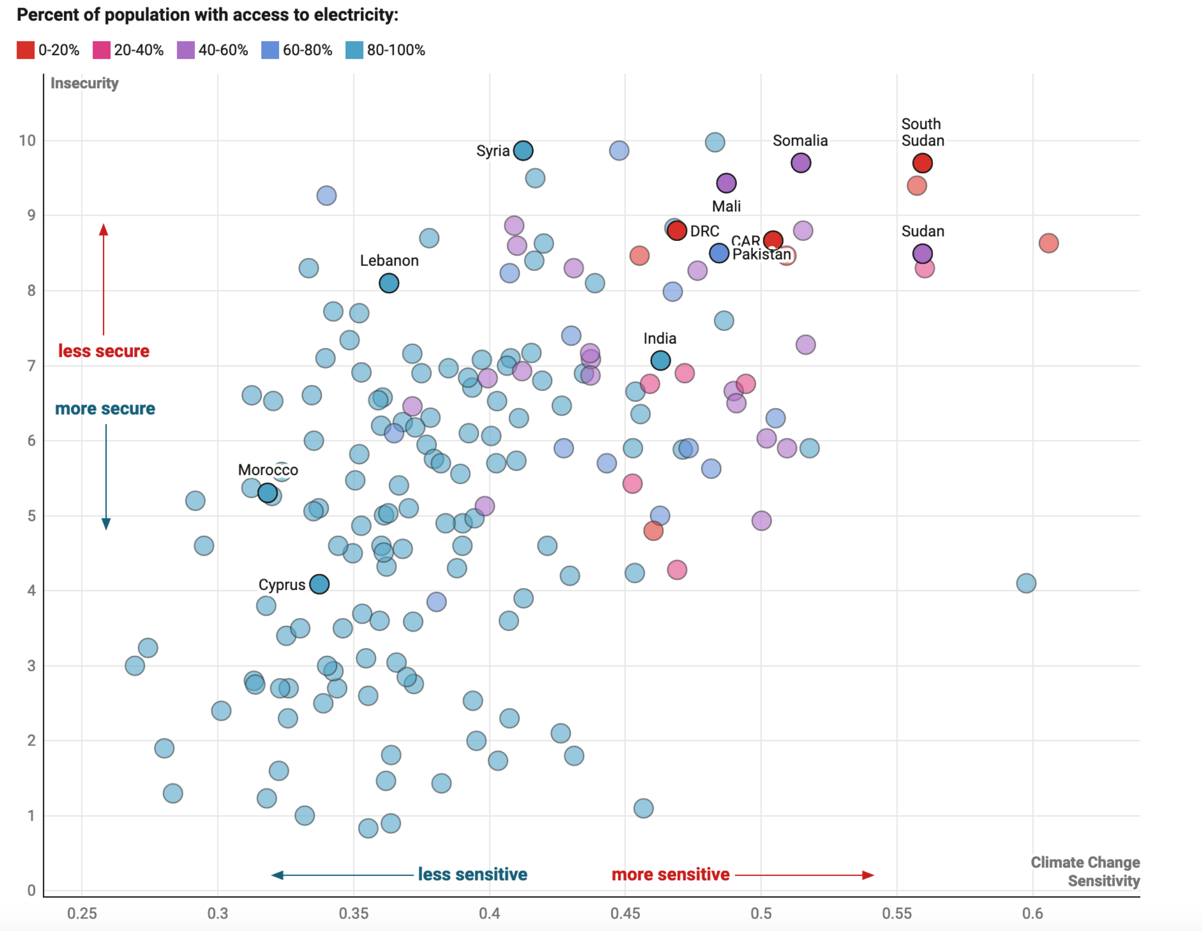
Fragile states themselves – led by the g7+ group of fragile states – are leading a global call to action to scale up energy investments within their borders. These states recognize that fragility and energy poverty are closely interlinked, and states can be caught in a fragility-energy poverty spiral which can lead to conflict, mass migration, and terrorism. In the wake of the Covid-19 pandemic and related economic and social shocks, an investment in energy access, and renewable energy access in particular, can help "build back better".[5]

Many of these same fragile states share another common characteristic that exacerbates their fragility and conflict potential: climate vulnerability. In fact, there is a strong overlap between countries suffering from conflict, energy poverty, and climate vulnerability, as can be seen Figure 1. The data in the bottom right-hand corner of the figure, which represent the least peaceful and most energy poor (from a Global Peace Index (GPI) score of 2.5 up and an energy access ratio of 50 percent and below), are all from climate vulnerable countries.

[1] SDSN. (2019). *Mapping the Renewable Energy Sector to the Sustainable Development Goals: An Atlas* (Issue June).
[2] The Fragile States Index defines a fragile state as "a country characterized by weak state capacity or weak state legitimacy leaving citizens vulnerable to a range of shocks". These shocks can be internal or external and include global pandemics, financial crises, natural disasters, amongst others.
[3] International Energy Agency, "Africa Energy Outlook 2019". Accessed at; https://www.iea.org/reports/africa-energy-outlook-2019#africa-case
[4] Ibid.
[5] Council on State Fragility, "Powering up Energy Investments in Fragile States Call to Action," G7+ group of fragile states. Launched 24/02/2021.

FIGURE 1: ENERGY POVERTY, CLIMATE VULNERABILITY AND INSECURITY

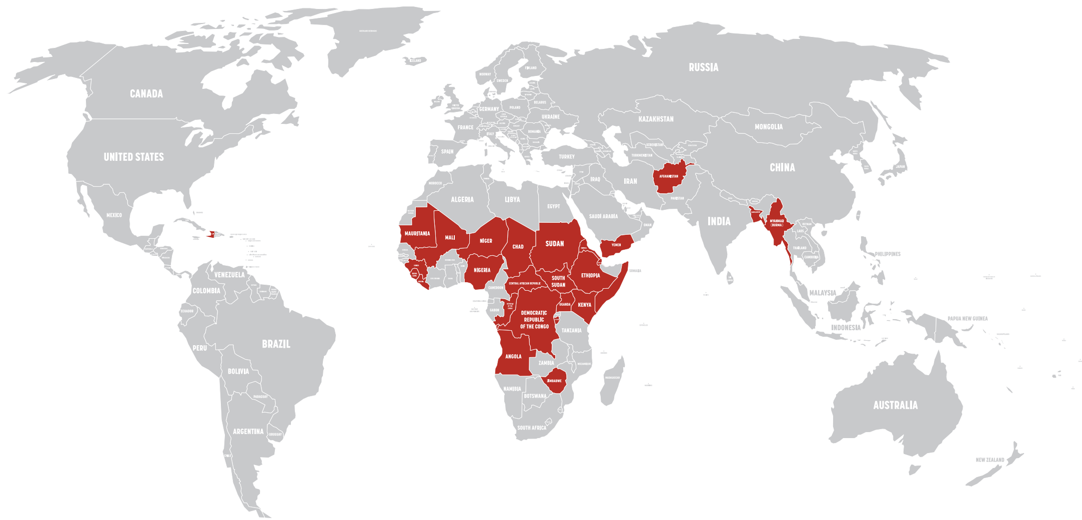
Average levels of insecurity, climate change sensitivity, and access to electricity from 2018-2020 among UN Member States.



Source: Stimson Centre Powering Peace Project, accessed at; https://www.stimson.org/project/powering-peace/understanding-the-energy-climate-security-relationship/

The group of countries at the triple-nexus of energy poverty, conflict, and climate vulnerability, are often in a difficult to break cycle of fragility and poverty, and it is this group in particular for whom the renewable energy revolution could bring the most meaningful peace dividends. Energy Peace Partners has identified 27 countries that most acutely face this triple threat, who have a collective population of over 850 million people. The 27 countries are primarily located in Africa, the Middle East and South Asia, as shown in Figure 2.

FIGURE 2: THE 'TRIPLE-THREAT' GROUP OF COUNTRIES: CLIMATE VULNERABLE, ENERGY POOR AND CONFLICT PRONE



Empirical data shows that there are large differences in terms of peacefulness, energy access, climate vulnerability, and renewable energy generation and consumption between the 'triple-threat' group of countries and the rest of the world. This is summarised in Table 1.

TABLE 1: MOST RECENT AVERAGES (BY COUNTRY GROUP): ENERGY ACCESS AND PEACEFULNESS[6]

	REST OF THE WORLD	TRIPLE-THREAT COUNTRIES
Access to electricity (% population)	88%	37%
Per Capita Electricity Generation (Kwh)	4458	198
Non-hydro RE generation (% total energy)	43%	4%
Hydro RE generation (% total energy)	19%	59%
RE consumption (% total energy, including hydro)	30%	72%
Climate vulnerability (Score between 0 and 1, where higher score is more climate vulnerable)	0.4	0.55
Positive Peace Index (lower = more peaceful)	2.7	4
Global Peace Index (lower = more peaceful)	2	2.4

[6] Data comes from World Bank World Development Indicators, IRENA, ND-GAIN, and the Institute for Economics and Peace. Full references included in the Methodological Annex.

2. Energy, Climate Vulnerability, and Peace

Access to reliable energy and electricity plays a pivotal role in promoting human development, peace, and stability. It enables communities to thrive by supporting education, healthcare, and economic opportunities, which is why the idea of affordable clean energy for all is enshrined in SDG 7.

Renewable energy sources, such as solar, wind, hydro,[7] and geothermal power, potentially offer numerous advantages over other energy sources in terms of peacebuilding. Renewable energy projects often have a smaller ecological footprint compared to fossil fuel-based power generation, reducing environmental degradation and potential conflict over scarce resources. Renewable energy can enhance energy security, reducing dependence on fossil fuel imports and decreasing geopolitical tensions related to energy access. Renewable energy projects can promote local ownership, participation, and cooperation, fostering social cohesion and reducing the risk of conflict over energy resources. Lastly, renewable energy can bring about a more equitable distribution of energy and hence in the long-term, a decrease in development gaps leading to less social unrest.

The synergistic relationship between electricity access and renewable energy creates a powerful pathway for sustainable peace. These pathways have been argued to include:

1. Economic Development: Access to electricity and renewable energy solutions stimulate economic growth, create employment opportunities, and alleviate poverty. This can reduce inequalities and social grievances that may contribute to conflicts.
2. Social Inclusion and Stability: Electricity access allows marginalized communities, particularly women and youth, to participate in decision-making processes, enhancing social inclusion and stability. Simultaneously, renewable energy projects at the community level can empower local populations, promoting social cohesion, and reducing conflict risks.
3. Climate Change Mitigation: Transitioning to renewable energy reduces greenhouse gas emissions, mitigating climate change. This contributes to peace by minimizing the conflicts arising from resource scarcity, displacement, and competition over natural resources exacerbated by climate change.
4. Energy Diplomacy: Renewable energy offers an opportunity for international collaboration and cooperation, as countries can share knowledge, technology, and resources. Collaborative efforts in the renewable energy sector can strengthen diplomatic ties, reduce energy-related conflicts, and foster peace on a global scale.

However, there are counter arguments to the potential peace benefits of renewable energy access. For example, there are those that argue that if the transition to renewables occurs under the same conditions of high energy consumption as currently exist, energy security vulnerabilities could still lead to increased conflict. There is also a higher risk of cyber-conflict in trying to take control of RE systems. Others argue that the dependence on critical materials to make some parts of RE systems (for example minerals for solar panels), may lead to conflict over control over these rare earth minerals, in the same way control over oil is fought over today.[8]

[7] Different countries, states, and organizations have adopted a varying range of criteria to determine whether hydropower is classified as renewable due to its impact on aquatic ecosystems, surrounding communities, and its sustainability over time. For example, in the U.S., states like California have set a limit of only systems under 30MW being considered renewable; and organizations like the Low Impact Hydropower Institute have a certification process for hydropower facilities to be considered low impact. This report tries, where possible, to distinguish whether or not hydropower is included; however not all data sources are disaggregated by renewable energy type.

[8] A 2018 report by the International Institute for Sustainable Development finds that a significant portion of minerals required for green technologies are located in states with high measures of fragility and corruption (IISD, 2018). For example, over 60 percent of the world's cobalt reserves – critical to battery production for electric cars and energy storage – is found in the Democratic Republic of Congo, which as of 2020 ranked 156th of 163 on the Positive Peace Index. Also see Vakulchuk, R.,

To date, the evidence linking increased energy access, let alone renewable energy access and generation, to socio-economic, peacebuilding, and conflict impacts is mixed. On the one hand, some studies and 'ground-truths'[9] have found that increased energy access, electrification, and an increase in renewable energy infrastructure, consumption and connectivity, can lead not only to economic and environmental benefits, but social benefits as well. These measured social benefits have been wide ranging from increasing health benefits, to educational benefits, and to increased gender equality.[10]

On the other hand, some studies or projects focused on energy access and renewable energy, particularly at a more micro-level - such as in specific villages or communities – have found social and economic impacts to be negligible, or in some cases negative.[11] Table 2 exemplifies the mixed empirical evidence looking at various socio-economic impacts related to energy access, electrification, and the renewable energy revolution.

TABLE 2: SUMMARY OF EMPIRICAL ANALYSIS OF IMPACTS ON SOCIAL AND ECONOMIC BENEFITS

Authors	**Assessments**	**Key Findings**
Bernard (2010)	Rural electrification in Sub-Saharan Africa	Overall rates of connectivity remain low, despite implementation of rural electrification projects.
IOB (2013)	Renewable energy access in developing countries	Finds evidence that health outcomes improve, but robust evidence on effectiveness is scarce for other variables.
Bonan et al. (2014)	Energy access in developing countries	No consistent findings along any outcome dimension – social or economic.
EBA (2015)	Climate change interventions in developing countries	Finds evidence that advanced energy services (rural electrification, e.g.) deliver health and income benefits.
Terrapon-Pfaff et al. (2018)	Small-scale renewable energy access in Global South	Environmental practices such as reforestation and crop rotation were sustained and adopted outside of target areas. Most projects contributed positively to the gender equality of women.
Raitzer & Sibal (2019)	Energy access in developing countries	Found contradictory outcomes on the impact of electrification on gender equality, improvements in quality of labor (movement from low to high skilled labor), and education, and increases in household incomes.

Overland, I., & Scholten, D. (2020). Renewable energy and geopolitics : A review. Renewable and Sustainable Energy Reviews, 122(January), 109547. https://doi.org/10.1016/j.rser.2019.109547.

[9] Ground truth is information that is known to be real or true, provided by direct observation and measurement.

[10] See for example a meta-study conducted in 2019 by the Asian Development Bank which reviewed 85 completed rigorous evaluations of energy interventions globally (Raitzer & Sibal, 2019), or a 2020 systemic review of 126 studies corresponding to 89 impact evaluations on the effects of electricity access interventions on social outcomes (Moore et al., 2020)

[11] These same meta analyses, as well as other studies can and have simultaneously found some positive effects, some inconclusive, and some negative effects of electrification. For example, depending on the study context: electrification can lead to improved educational outcome for children, or not; educational outcomes of electrification can reinforce gender equality, or not; electrification can impact female empowerment, or not; electrification can affect labor outcomes, or not.

Moore et al. (2020)	Electrification in developing countries	Finds modest positive effects on household socio-economic outcomes, with great variability across the studies. Positive social change requires understanding local, specific contexts.
Liao et al. (2021)	Energy transitions in lower and middle income countries	Finds positive benefits in education and income, with a greater likelihood of energy subsidies and country membership in energy organizations.
Ayana & Degaga (2022)	Rural electrification benefits	Findings statistically support positive effects on education, employment, income, productive time uses and female empowerment.

The mixed empirical evidence results - in part - because of a lack of systematic and widely agreed upon framework for examining what kinds of social and peace impacts ought to result from energy and renewable energy access. More fundamentally, there is also a lack of shared understanding and 'norm' around what peace is and how to measure it.

What does peace mean?

There are two broadly accepted conceptions of peace: negative peace – referring to the absence of violence and conflict; and, positive peace – referring to 'a more lasting peace built on sustainable investments in economic development and institutions, as well as societal attitudes that foster peace.'[12]

Negative peace is critical in conflict and fragile settings; the first step in any potential stabilization, reconstruction, and peace-building effort is security and the absence of violence. Negative peace is a necessary but insufficient condition for long-term sustainable flourishing of any society. Communities and countries can, and often do, cycle in and out of periods of more or less negative peace, returning to bouts of violence and conflict. This is because they lack the attitudes, structures and institutions[13] that are necessary for long-term sustainable peace; that is, they suffer from a dearth of positive peace.

An actionable measure of positive peace is the framework developed by the Institute for Economics and Peace (IEP), whose eight component parts systemically interact to build societies attitudes, structures, and institutions that create sustainable peace. The eight pillars – in no particular ordering of importance - are: well-functioning government, free flow of information, low levels of corruption, high levels of human capital, sound business environment, acceptance of the rights of others, equitable distribution of resources and good relations with neighbours.

[12] Definition taken from positivepeace.org/what-is-positive-peace.

[13] Or at least lack sufficient levels of these attitudes, structures and institutions. When a country's level of negative peace is greater than its positive peace, this disequilibrium is referred to as a positive peace deficit, and foreshadows the risk of conflict or a return to conflict.

FIGURE 3: THE EIGHT PILLARS OF POSITIVE PEACE

This definition and measure of positive peace is known to be a statistically significant correlate of the absence of conflict and violence. It also provides a framework for assessing a country's, or community's, resilience; its ability to plan, absorb, and respond to shocks.[14] Climate change related disasters are one such type of shock for which a country, or community, needs resilience. This positive peace framework also links directly to many of the Sustainable Development Goals, with research concluding that of the 169 targets outlined across all SDGs, 85% are relevant to more than two Positive Peace factors.[15]

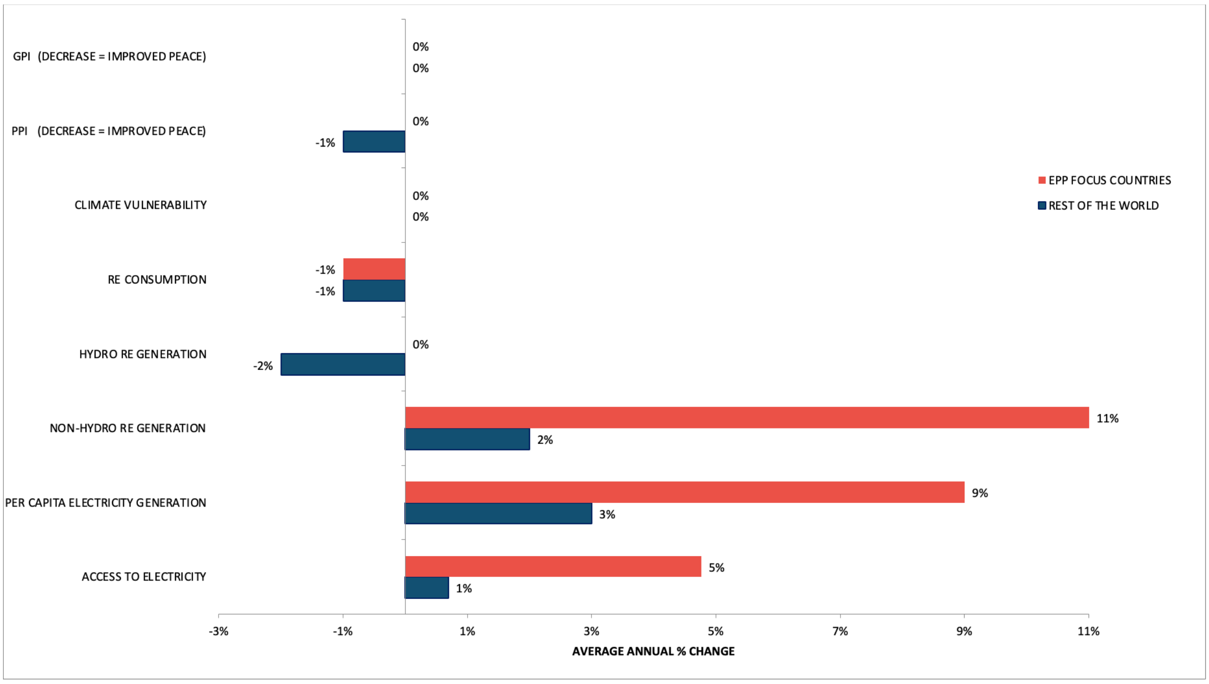
2.1 Exploring the link between energy access, renewable energy, and peace

While overall levels of peacefulness in the world have increased marginally in the decade between 2009 and 2022, peacefulness has become less evenly distributed around the world. In the triple-threat group of countries, initial improvements in conflict levels were quickly subsumed by a marked increase in conflict intensity from 2013 onward. At the same time, both triple-threat and other countries have seen marginal improvements in resilience and sustainable peace.

The decade has also seen levels of access to electricity increase globally, with access increasing more rapidly – from a very low base – in the triple threat group of countries (average of five percent per annum) than others (average of one percent per annum).

[14] IEP. (2019a). *Positive Peace Report 2019*.
[15] IEP. (2019b). *SDG 16+ Progress Report 2019*.

FIGURE 4: AVERAGE ANNUAL PERCENTAGE CHANGE IN KEY INDICATORS, TRIPLE-THREAT COUNTRIES AND THE REST OF THE WORLD, 2009-2020



So what relationship, if any, exists between energy access, renewable energy generation, consumption, and peacefulness?[16]

Using an original data set[17] covering 156 countries over the period from 2009 to 2019, we empirically test the relationship between energy access, renewable energy consumption and production, and peace, using panel data regression. Specifically, we test the following hypotheses:

H1: There is a negative correlation between renewable energy consumption and levels of conflict or violence in a country.[18]
H2: There is a positive correlation between renewable energy consumption and levels of positive peace in a country.
H3: An increase in renewable energy consumption will lead to decreases in levels of conflict or violence in a country.
H4: An increase in renewable energy consumption will lead to increases in positive peace in a country.
H5: An increase in non-hydro renewable energy generation will lead to increases in negative peace in a country.
H6: An increase in non-hydro renewable energy generation will lead to increases in positive peace in a country.

[16] For a thorough review of existing arguments and evidence for relationships (positive or negative) between energy access, renewable energy and peace, please see the comprehensive literature review EPP has undertaken on the topic, published on our website at https://www.energypeacepartners.com/peace-impacts.
[17] An original data set refers to a data set collected, compiled and analyzed by EPP.
[18] Conflict and Violence, or an absence of conflict and violence more specifically, is what is defined in peace terminology as 'negative peace'.

3. Findings

Summary

- Across the full sample of 159 countries, there is a positive and statistically significant correlation between access to electricity, as well as non-hydro renewable energy generation, and peace (both negative peace and positive peace). There is also a negative and statistically significant correlation between renewable energy consumption and peace (both negative peace and positive peace).
- In the 'triple-threat' group of countries (as indicated in Figure 2), only two variables are significantly and positively correlated with positive peace: higher shares of non-hydro renewable energy generation, and democracy.
- The best predictor of future levels of conflict across the globe is previous levels of conflict, while the most significant predictor of future levels of sustainable peace globally are levels of economic equality.
- In the triple-threat group of countries, non-hydro renewable energy generation has the potential to increase levels of sustainable peace in the future.

3.1. Correlates of Peace

Correlations indicate the extent to which two variables may be related and the direction of that relationship. Measured empirically, a correlation coefficient indexes the tendency of the variables to "co-vary"; that is, for changes in the value of one variable to be associated with changes in the value of the other. Importantly, correlations do not say anything about a causal effect between variables.[19]

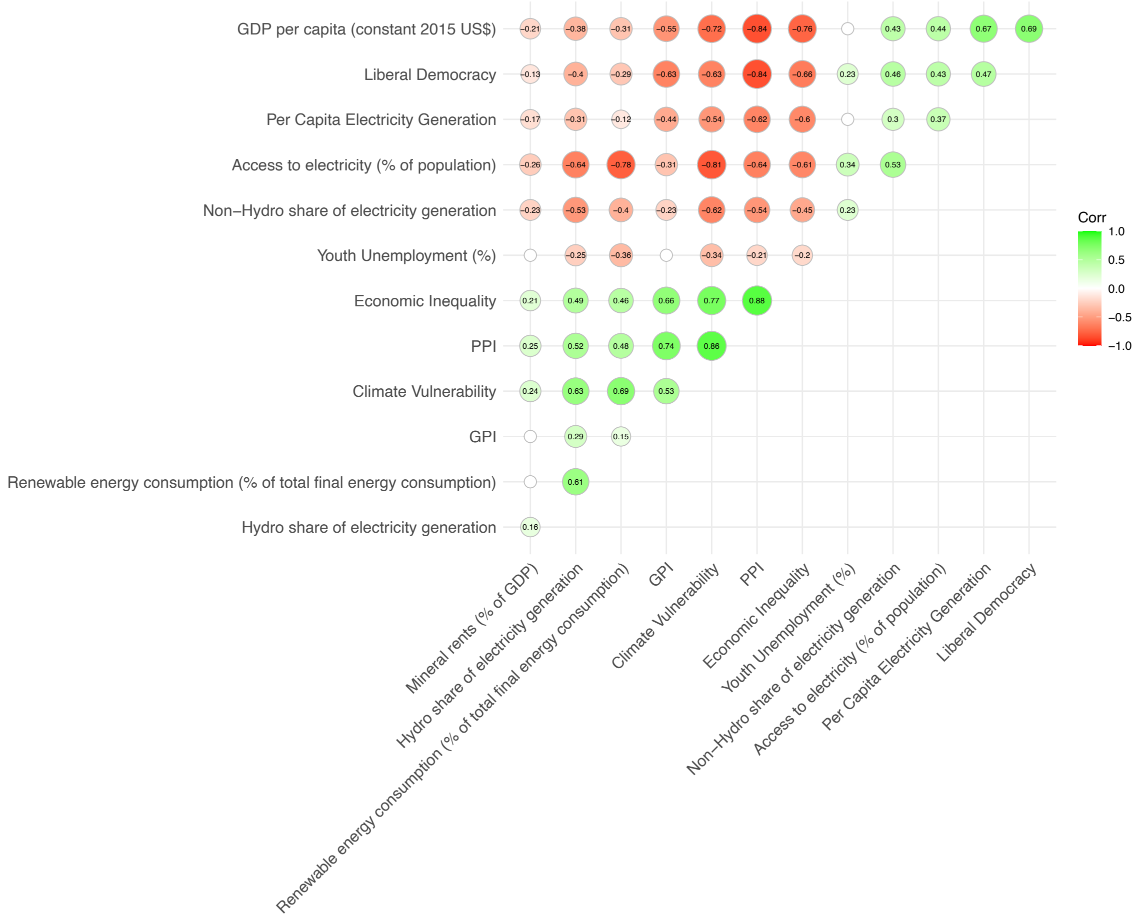
The data investigated for this study across the full sample of 159 countries and 11 years, found two significant energy related positive correlates of peace: access to electricity and non-hydro renewable energy generation. The magnitude of the association between access to electricity and positive peace is 0.64 indicating a strong relationship, as is the magnitude of the relationship between non-hydro renewable energy generation and positive peace (0.54). This indicates that upwards trends in access to electricity or non-hydro renewable energy generation are associated with upwards trends in positive peace (and conversely for negative trends). In addition, two more conventional variables used to explain variations in levels of peace and conflict – democracy and economic development - are also found to be statistically significantly and positively associated with peace.

[19] In interpreting correlation coefficients, two properties are important. **Magnitude**: Correlations range in magnitude from -1.00 to 1.00. The larger the absolute value of the coefficient (the size of the number without regard to the sign) the greater the magnitude of the relationship. For example, correlations of .60 and -.60 are of equal magnitude, and are both larger than a correlation of .30. When there is no linear relationship, the correlation will be 0.00; when there is a perfect linear relationship (one-to-one correspondence between the values of the variables), the correlation will be 1.00 or -1.00. **Direction**. The direction of the relationship (positive or negative) is indicated by the sign of the coefficient. A positive correlation implies that increases in the value of one score tend to be accompanied by increases in the other. A negative correlation implies that increases in one are accompanied by decreases in the other. When a correlation between two variables is tested and found to be 'statistically significant' in a data set, this indicates that there is sufficient evidence to suggest that a true correlation exists that is different from zero; that the relationship found is not just an artifact of the particular data set under examination. Source: https://www.washington.edu/assessment/scanning-scoring/scoring/reports/correlations/

The analyzed data further shows two significant energy related negative correlates of peace: renewable energy consumption[20] and hydro renewable energy generation. This indicates that upwards trends in renewable energy consumption or hydro based renewable energy generation are associated with downwards trends in positive peace (and conversely for negative trends). The negative correlation between peace and renewable energy consumption may be because the increases in renewable energy consumption are being driven by hydro renewable energy generation.

Figure 5 shows the bivariate correlation matrix between measures of peacefulness and measures of energy access, renewable energy consumption, and generation. The correlation matrix is generated based on all countries in the data, for all years between 2009 and 2020. While the colour of the bubbles indicates the direction or correlation (with green indicating a positive relationship where variables move together in the same direction, while red indicating a negative relationship), the absolute number indicates the strength of the correlation and this is further distinguished by the size of the circle – the larger the circle the greater the strength. Where no statistically significant correlation exists, the bubble is left blank.[21] For example, economic inequality and climate vulnerability have a strong, and positive correlation (0.77); whereas access to electricity and climate vulnerability have a strong, but negative correlation (-.81).

FIGURE 5: CORRELATES OF PEACE IN 159 COUNTRIES OVER 11 YEARS

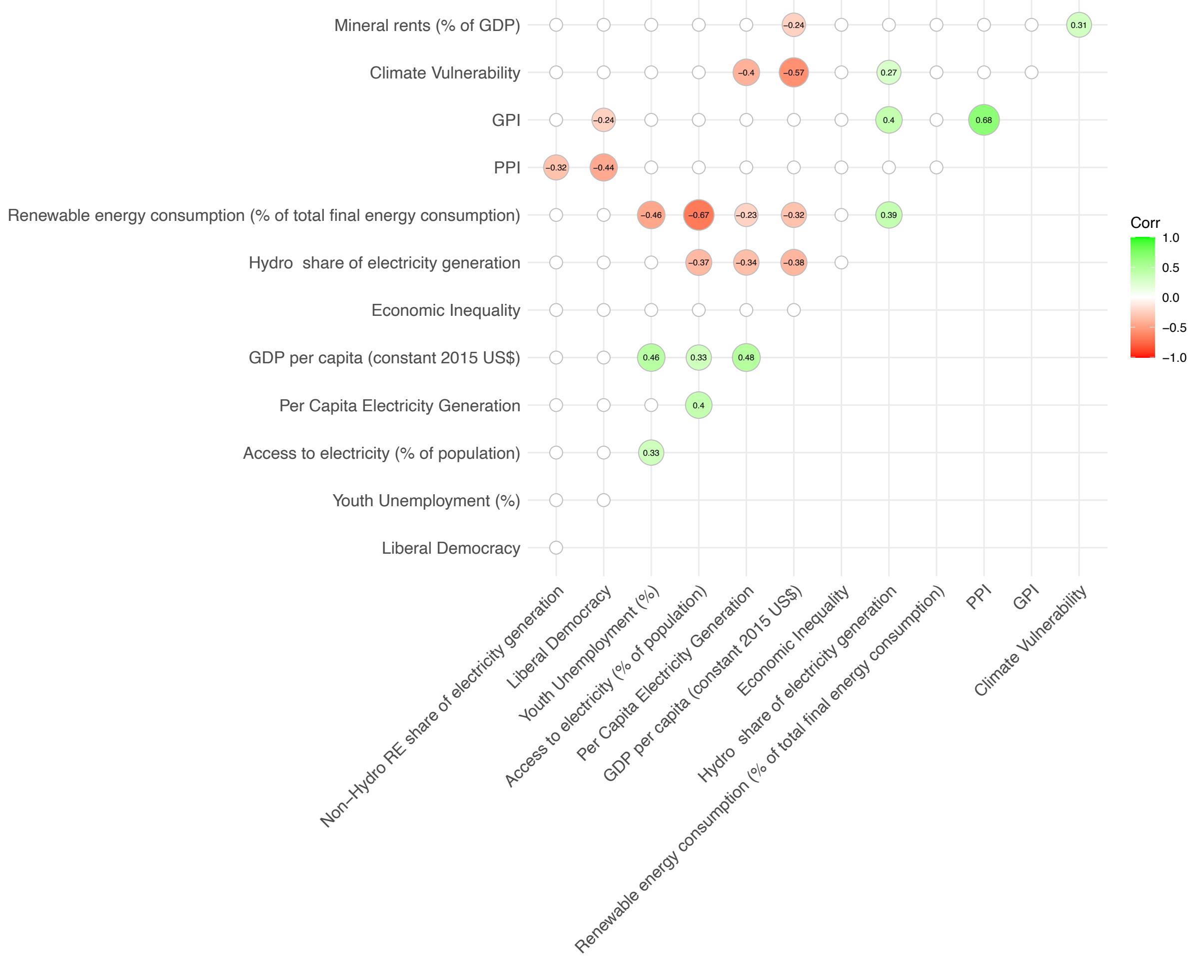


20 Consumption data includes hydropower.

21 Again statistical significance indicates that any relationship found is statistically distinguishable from zero. If two variables are not found to be correlated in a statistically significant sense than we cannot say that the association between them is different to zero.

When analysing the correlates of peace for the group of 'triple threat' countries on which EPP's work focuses, two key findings emerge. While levels of democracy are positively correlated with both negative and positive peace in this group, non-hydro RE generation is positively correlated only with positive peace, while hydro RE generation is negatively correlated with negative peace. In other words, what this tells us is that the type of renewable energy matters – that is increased generation of renewable energy such as solar and wind are correlated with increased positive peace; and an increase in hydro generation is correlated with increased insecurity. Figure 6 shows the bivariate correlation matrix focusing only on this group of countries.

FIGURE 6: CORRELATES OF PEACE IN EPP'S 'TRIPLE THREAT' COUNTRIES OVER 11 YEARS



3.2 Beyond Correlation: Causal links between renewable energy and peace?

Correlations alone say nothing about causality; that is, based on correlations alone, we cannot say anything about what variables actually affect levels of peacefulness or conflict. In order to try to unpack causality, more rigorous econometric regression analysis is required that allows the concurrent statistical testing of multiple potential 'causal' variables on levels of peacefulness. In this way, while we are fundamentally interested in the effect of energy related variables (and renewable energy specifically) on peace and conflict, we take account statistically of other factors that have theoretically and empirically been shown to be associated with peace and conflict. These additional variables are econometrically referred to as 'control' variables: for example, we control for levels of democracy when we investigate the potential effect of RE on peace as we know from previous studies that democratic countries in general tend to be more peaceful (and they may also have higher RE consumption patterns)[22].

The results from the econometric analysis across the full sample of countries, which are detailed in the tables in the methodological annex, show that the best predictor of *future levels of conflict* across the globe is previous levels of conflict. This indicates the nature of slow-moving pace of change in levels of peace (the 'stickiness' of peace, a phenomenon that has been well documented in peacebuilding studies and noted almost annually in the rigorous Global Peace Index and Positive Peace Index reports). When change does happen, it happens incrementally; this means that countries can often find themselves in difficult to break trajectories of increasing conflict, particularly if an external shock such as a natural disaster occurs in the absence of a resilient state.

The most significant predictor of *future levels of sustainable peace* globally according to the econometric analysis are levels of economic equality; a higher level of economic equality is associated with a higher level of resilience or sustainable peace the following year. Lower levels of group grievances – indicative of ethnic, social or religious polarization and marginalization, the higher the levels of sustainable peace. Higher rates of urbanization, higher levels of GDP growth and lower levels of youth unemployment are also all statistically significant predictors of a more sustainable peace. Once we account for these control variables, the analysis shows that there is no significant effect of renewable energy consumption or generation on future conflict or peacefulness across the whole sample of countries.

Focusing in more narrowly on only the 'triple-threat' group of countries where EPP works, econometric results, controlling for the same variables, show that higher levels of electricity generation per capita can increase levels of sustainable peace. Furthermore, results indicate that it is non-hydro renewable energy generation that does the heavy lifting of contributing to future levels of positive peace - that is, it can help build sustainable peace in the medium to long term. If a country were to move theoretically from 0 percent to 100 percent non-hydro renewable energy generation, this could increase the level of sustainable peace by as much as 12 percent.[23]

Regression results also show that increased access to electricity can exacerbate future conflict: this finding certainly merits further investigation, but could be related to the type of electricity coming on-line to populations in these countries. For example, where there is increased reliance on fossil fuels to provide for electricity access, both the increased presence of the fossil fuel itself as well as their expanded transport routes have widely been recognised as affecting conflict.[24]

Conclusions and future research

The empirical analysis conducted in this paper was a first attempt to statistically examine the relationship between peace, conflict, and renewable energy, both globally, as well as specifically focusing on a group of countries that are threatened by high climate vulnerability, low electricity access, and high fragility.

[22] For a more detailed explanation of the econometric modelling please refer to the methodological appendix.
[23] A 12 percent increase in levels of Positive Peace would correspond to an index score change of 0.6, where the maximum range of the Positive Peace Index runs from 1 (most peaceful) to 5 (least peaceful).
[24] https://www.sciencedirect.com/science/article/abs/pii/S2214629614001170

What becomes clear from the analysis is that changes in levels of peacefulness occur slowly absent an external shock: thus, peacebuilding approaches must take a long-term view of programming and impact. The construction and deployment of renewable energy projects is one such potential long-term tool for peacebuilding; results have shown the potential positive effects of non-hydro RE generation in particular in the triple-threat group of countries.

Further investigation is required relating to the mechanisms by which RE generation could contribute to long term sustainable piece. EPP has started this more nuanced research at a RE project level through the deployment of its monitoring and evaluation framework to measure and quantify peace in project communities, as well as qualitatively understand from the communities how and why a host of socio-economic factors can and have changed.

References

Aklin, M., Bayer, P., Harish, S. P., & Urpelainen, J. (2017). *Does basic energy access generate socioeconomic benefits ? A field experiment with off-grid solar power in India. May*, 1–9.

Avila, N., Carvallo, J., Shaw, B., & Kammen, D. M. (2017). The energy challenge in sub-Saharan Africa: Generating energy for sustainable and equitable development. *Oxfam Research Backgrounder Series*, 100. https://www.oxfamamerica.org/static/media/files/oxfam-RAEL-energySSA-pt1.pdf

Ayana, O., Degaga, J. (2022). Effects of rural electrification on household welfare: a meta-regression analysis. *International Review of Economics. 69,* 209-261. https://doi.org/10.1007/s12232-022-00391-7

Barnes, D. F., & Samad, H. (2018). *Measuring the Benefits of Energy Access.*

Bensch, G., Peters, J., & Sievert, M. (2012). Fear of the dark? How access to electric lighting affects security attitudes and nighttime activities in rural Senegal. In *Economic Record* (Vol. 329). https://doi.org/10.1111/j.1475-4932.1982.tb00356.x

Bernard, T. (2010). *Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa*. 33–51. https://doi.org/10.1093/wbro/lkq008

Bonan, J., Pareglio, S., & Tavoni, M. (2014). Access to Modern Energy: a Review of Impact Evaluations. *Nota Di Lavoro*, *96*.

Bradley, T., & March, K. L. (2019). *Using Energy Programming to Address Violence Against Women and Girls in Humanitarian Settings*. *March*.

Burke, M. J., & Stephens, J. C. (2018). Energy Research & Social Science Political power and renewable energy futures : A critical review. *Energy Research & Social Science*, *35*(November 2017), 78–93. https://doi.org/10.1016/j.erss.2017.10.018

Cox, S., Hotchkiss, E., Bilello, D., Watson, A., & Holm, A. (2017). *Bridging Climate Change Resilience and Mitigation in the Electricity Sector Through Renewable Energy and Energy Efficiency Emerging Climate Change and Development Topics for*. *November*.

Danske Commodities. (2019). *Light over Mali*.

EBA. (2015). *In Search of Double Dividends from Climate Change Interventions*.

Edwards, I. (n.d.). *The role of decentralized renewable energy in peacebuilding*.

Gennaioli, C., & Tavoni, M. (2016). Clean or dirty energy : evidence of corruption in the renewable energy sector. *Public Choice*, *166*(3), 261–290. https://doi.org/10.1007/s11127-016-0322-y

GIIN. (2014). *Impact Measurement in the Clean Energy Sector*.

Gillard, R., Oates, L., Kasaija, P., Sudmant, A., & Gouldson, A. (n.d.). *Sustainable urban infrastructure for all :*

Lessons on solar-powered street lights from Kampala and Jinja , Uganda Summary. 1–20.

GOGLA. (2020). *Standardised Impact Metrics for the Off-Grid Solar Energy Sector* (Issue April).

GOGLA, & Altai Consulting. (2018). *Research Guidelines and Tools*.

Gold Foundation. (2014). *THE REAL VALUE OF ROBUST CLIMATE ACTION*.

Hassan, F., & Lucchino, P. (2016). *Powering Education*.

IEG. (2008). *The Welfare Impact of Rural Electrification : A Reassessment of the Costs and Benefits*.

IEP. (2019a). *Positive Peace Report 2019*.

IEP. (2019b). *SDG 16+ Progress Report 2019*.

IISD. (2018). *Green Conflict Minerals : The fuels of conflict* (Issue August).

IOB. (2013). *Renewable Energy: Access and Impact* (Issue 376).

IRENA. (2020). *The Post-covid Recovery*.

Jimenez, R. (2017). *Development Effects of Rural Electrification Development Effects of Rural Electrification Raul Jimenez*. *January*.

Liao, C., Erbaugh, J., Kelly, C., Agrawal, A. (2021). Clean energy transitions and human well-being outcomes in Lower and Middle Income Countries: A systematic review. *Renewable and Sustainable Energy Reviews. July* https://doi.org/10.1016/j.rser.2021.111063

Lyons, S. W. (2015). Preventing a Renewable Resource Curse. *Sustainable Development Law & Policy*, *15*(2).

M&EED. (2006). *A Guide to Monitoring and Evaluation for Energy Projects* (Issue December).

Mansson, A. (2015). A Resource Curse for Renewables ? Conflict and Cooperation in the Renewable Energy Sector. *Energy Research & Social Science*, *10*, 1–9. https://doi.org/10.1016/j.erss.2015.06.008

Marijnen, E., & Schouten, P. (2019). Electrifying the green peace? Electrification, conservation and conflict in Eastern Congo. *Conflict, Security and Development*, *19*(1), 15–34. https://doi.org/10.1080/14678802.2019.1561615

Moner-Girona, M., Kakoulaki, G., Falchetta, G. (2021). Achieving universal electrification of rural healthcare facilities in sub-Saharan Africa with decentralized renewable energy technologies. *Joule. 5,* 2687-2714. https://doi.org/10.1016/j.joule.2021.09.010

Moore, N., Glandon, D., Tripney, J., & Kozakiewicz, T. (2020). *Effects of Access to Electricity Interventions on Socio e conomic Outcomes in Low- and Middle- Income Countries*. *August*.

Morris, R. (2017). *Energy, fragility and conflict: Briefing note*. *June*. https://assets.publishing.service.gov.uk/media/5a26946f40f0b659d1fca8d5/Line_34_-_EEG_FCAS_Briefing_Note.28.06.2017.v1.pdf

Oxfam. (2019). *Shining a Light*.

Petrie, B. (2013). *Green jobs: access to clean energy can create employment in South Africa*.

Power for All. (2017). *Why wait?*

Raitzer, D. A., & Sibal, J. (2019). *Impact Evaluation of Energy Interventions A review of the evidence* (Issue April).

Sacchetto, C., Stern, N., & Taylor, C. (2020). *Priorities for renewable energy investment in fragile states Energy* *access : State fragility and fossil fuels. November.*

Salvador, N. El, Barron, M., & Torero, M. (2015). *Munich Personal RePEc Archive Electrification and Time Allocation : Experimental Evidence from Electrification and Time Allocation : Experimental Evidence from Northern El Salvador. 63782.*

SDSN. (2019). *Mapping the Renewable Energy Sector to the Sustainable Development Goals: An Atlas* (Issue June).

Sen, B. (2017). *How States Can Boost Renewables, with Benefits for All: Renewable Energy Portfolio Standards and Distributed Solar Access for Low-Income Households*. www.ips-dc.org

Shell Foundation. (2020). *Improving the Quality of Life of Kenyan Households with Off-Grid Solar Home Systems.*

Shoaib, A., Ariaratnam, S., Ph, D., & Asce, F. (2016). A Study of Socioeconomic Impacts of Renewable Energy Projects in Afghanistan. *Procedia Engineering*, *145*, 995–1003. https://doi.org/10.1016/j.proeng.2016.04.129

Su, C., Khan, K., Umar, M., Zhang, W. (2021) Does renewable energy redefine geopolitical risks? *Energy Policy*. *November.* https://doi.org/10.1016/j.enpol.2021.112566

Sustainable Energy for All. (2019). *Sustainable Off-Grid Solar Delivery Models To Power Health and Education*. 84. www.unfoundation.org

Terrapon-pfa, J., Gröne, M., Dienst, C., & Ortiz, W. (2018). *Impact pathways of small-scale energy projects in the global south – Findings from a systematic evaluation*. *95*(July), 84–94. https://doi.org/10.1016/j.rser.2018.06.045

UNDESA. (2014). *Electricity and education : The benefits , barriers , and recommendations for achieving the electrification of primary and secondary schools* (Issue December).

UNHCR. (2017). *AFFECTS REFUGEE COMMUNITIES* (Issue December).

Vakulchuk, R., Overland, I., & Scholten, D. (2020). Renewable energy and geopolitics : A review. *Renewable and Sustainable Energy Reviews*, *122*(January), 109547. https://doi.org/10.1016/j.rser.2019.109547

Waal, E. C. Van Der. (2020). Local impact of community renewable energy : A case study of an Orcadian community-led wind scheme. *Energy Policy*, *138*(April 2019), 111193. https://doi.org/10.1016/j.enpol.2019.111193

Welsh, B., & Farrington, D. (n.d.). *Improved Street Lighting and Crime Prevention*.

White, H., Menon, R., & Waddington, H. (2018). *Community-driven development : does it build social cohesion or infrastructure ? A mixed-method evidence synthesis March 2018 Working* (Issue March).

Methodological Annex

This Annex summarizes the data the econometric specifications used in the analysis above.

Data

The data used in the econometric analysis are summarised in Table A.

TABLE A: INDICATORS USED FOR ANALYSIS

Econometric terminology	Variable	Indicator	Measure/Scale	Data availability	Source
Dependent variables	Negative Peace	Global Peace Index	A score of 1 to 5: 5 representing highest levels of violence (hence lowest levels of negative peace)	163 countries, at least 10 years of data (2010-2021)	IEP
	Positive Peace	Positive peace Index	A score of 1 to 5: 5 representing lowest levels of positive peace	163 countries, at least 10 years of data (2010-2021)	IEP
		Eight individual pillars	Each pillar receives a score of 1 to 5: 5	163 countries,	IEP

		of positive peace (indexed)	representing lowest levels of peace in that pillar	at least 10 years of data (2010-2021)	
Independent variable	Renewable energy access	Renewable energy consumption	Renewable energy consumption as a percentage of total energy consumption	In theory 266 countries, data up to 2018	World Bank, WDI
		Renewable energy production	• Non-hydro renewable energy generation (share of total generation) • Hydro renewable energy generation (share of total generation)	In theory 266 countries, data up to 2019	IRENA
Control variables	Capacity of State institutions		• Percentage of population with access to clean water • Percentage of population with access to health care		World Bank, WDI

			• Percentage of population with access to education		
	Political Regime Type	Democracy level	Polity Score Ranges from -10 to 10, with higher levels more democratic		Polity
	Degree of Polarization or Grievances		Group Grievance Score	Data from 2006-2021	Fragile States Index
	Economic Growth	GDP per capita growth	Annual percentage growth in GDP per capita		World Bank, WDI
	Resource Stress	Water stress	Level of water stress: freshwater withdrawal as a percentage of available freshwater resources	Data from 2000-2018	FAO
	Climate Vulnerability	ND-Gain Vulnerability Score	Score between 0 and 1, where higher score is more climate vulnerable	Data from 1995 to 2019	University of Notre Dame

	Electricity access	Percentage of population with access to electricity	Percentage		World Bank, WDI
	Electricity generation capacity	Per capita electricity generation	KilloWatt Hours	Data from 2011 to 2021	Our World in Data

Regressions

Panel data regression with country-year as the unit of observation was conducted using a cross-sectional time-series dataset covering 158 countries and 11 years. A multitude of panel regression models were run on the range of independent and control variables using both fixed effects for country as well as random effects specifications.

The key dependent variables in the analysis are measures of negative peace and positive peace, as quantified by the Global Peace Index and the Positive Peace Index. The key independent variables in the analysis were levels of renewable energy consumption and renewable energy production. Control indicators for explaining variations in peacefulness were identified from the academic and policy literature on conflict and cooperation (listed in Table A above).

Standard statistical tests[25] were used to determine that fixed effects were more appropriate than random effects. Standard statistical tests were used to check for serial correlation which indicated that at least one lag of the dependent variable was needed to 'soak up' these effects[26]. Heteroskedasticity was adjusted for using heteroskedatsic robust standard errors. Finally an examination of the adjusted R-squared values of the models fit was done in order to select the models that held the most explanatory power, which are those presented in Tables B and C below. All data and econometric analysis was done using the R statistical software package.

As can be seen in both Table B and Table C below, the lagged value of the Positive Peace Index and Global Peace Index respectively, is most significantly correlated with the current value of the index, both in terms of the magnitude of the correlation as well as the statistical significance.

[25] To test between fixed and random effects, Hausman tests were run where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9) .

[26] To test for serial correlation in panel data, Breusch-Godfrey tests were run which indicated the presence of serial correlation, hence the use of panel corrected standard errors.

TABLE B: PANEL REGRESSION RESULTS FOR 'TRIPLE-THREAT' COUNTRIES; RENEWABLE ENERGY AS A PREDICTOR OF PEACE

	Dependent variable:			
	Positive.Peace		GPI	
	Share Production	Consumption	Share Production	Consumption
	(1)	(2)	(3)	(4)
lag(Positive Peace)	0.748*** (0.088)	0.743*** (0.095)		
lag(GPI)			0.697*** (0.109)	0.709*** (0.092)
lag(Economic Inequality)	−0.027 (0.018)	−0.017 (0.022)	−0.014 (0.032)	−0.019 (0.036)
lag(Mineral rents)	−0.001 (0.001)	−0.0003 (0.001)	0.008 (0.009)	0.008 (0.010)
lag(safe water)	−0.014 (0.009)	−0.012 (0.008)	0.00000 (0.005)	−0.007 (0.006)
lag(share RE hydro)	0.089 (0.063)		−0.018 (0.093)	
lag(share RE nonhydro)	−0.609* (0.371)		−0.548 (0.389)	
lag(RE consumption)		−0.001 (0.001)		−0.005 (0.004)
lag(Group Grievance)				0.011 (0.025)
lag(Climate Vulnerability)			1.692 (1.339)	2.255* (1.281)
lag(Urban population)	−0.005* (0.003)	−0.004 (0.003)	0.008 (0.007)	0.006 (0.008)
lag(Youth UE)	−0.002 (0.002)	−0.0004 (0.003)	−0.005 (0.004)	−0.009 (0.008)
lag(Democracy)	−0.172 (0.239)	−0.289 (0.269)	0.304** (0.146)	0.212 (0.226)
lag(GDP/capita growth)	−0.0005 (0.001)	−0.0003 (0.001)	−0.002 (0.002)	−0.002 (0.002)
lag(Electricity Access)	−0.0001 (0.0004)	−0.0003 (0.001)	0.003*** (0.001)	0.004*** (0.001)
lag(GDP/capita)			−0.0001* (0.0001)	−0.0001 (0.0001)
lag(Electricity gen/capita)	0.0002** (0.0001)	0.0002** (0.0001)	−0.0001 (0.0002)	−0.00005 (0.0002)
Observations	112	110	112	110
R2	0.682	0.660	0.764	0.769
Adjusted R2	0.603	0.579	0.698	0.704
F Statistic	15.911*** (df = 12; 89)	15.540*** (df = 11; 88)	20.069*** (df = 14; 87)	20.223*** (df = 14; 85)

*p<0.1; **p<0.05; ***p<0.01

TABLE C: PANEL REGRESSION RESULTS FOR ALL COUNTRIES; RENEWABLE ENERGY AS A PREDICTOR OF PEACE

	Dependent variable:			
	Positive.Peace		GPI	
	Share Production	Consumption	Share Production	Consumption
	(1)	(2)	(3)	(4)
lag(Positive Peace)	0.546***	0.829***		
	(0.071)	(0.044)		
lag(GPI)			0.768***	0.764***
			(0.036)	(0.039)
lag(Economic Inequality)	0.003	0.008**	0.003	-0.0001
	(0.005)	(0.004)	(0.006)	(0.006)
lag(Mineral rents)	-0.003	-0.002	-0.003	-0.002
	(0.002)	(0.001)	(0.003)	(0.003)
lag(safe water)	-0.004**	-0.001	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)
lag(Climate Vulnerability)	0.133	-0.586*	0.348	0.476
	(0.409)	(0.328)	(0.386)	(0.447)
lag(Share RE hydro)	0.022		-0.005	
	(0.019)		(0.027)	
lag(Share RE nonhydro)	0.018		0.003	
	(0.016)		(0.016)	
lag(RE consumption)		-0.0001		-0.00003
		(0.001)		(0.001)
lag(Group Grievance)			0.004	0.002
			(0.004)	(0.005)
lag(Urban Pop)	-0.001	-0.006***	-0.004	-0.005
	(0.003)	(0.002)	(0.003)	(0.003)
lag(Youth UE)	-0.002**	0.0004	0.0001	0.0002
	(0.001)	(0.0004)	(0.001)	(0.001)
lag(Democracy)	-0.114	-0.023	-0.094	-0.090
	(0.081)	(0.054)	(0.062)	(0.068)
lag(GDP/capita growth)	-0.001**	-0.001**	-0.003***	-0.003***
	(0.001)	(0.0004)	(0.001)	(0.001)
lag(Electricity Access)	-0.001*	-0.0004	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
lag(GDP/capita)			0.00000	0.00000
			(0.00000)	(0.00000)
lag(Electricity gen/capita)	-0.00001**	-0.00001**	0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Observations	894	849	894	849
R2	0.377	0.667	0.639	0.632
Adjusted R2	0.299	0.623	0.593	0.582
F Statistic	36.890*** (df = 13; 794)	125.158*** (df = 12; 750)	93.591*** (df = 15; 792)	91.627*** (df = 14; 748)

*p<0.1; **p<0.05; ***p<0.01