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IAEE Energy Forum

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IAEE International Association for ENERGY ECONOMICS

PRESIDENT'S MESSAGE

My last Energy Forum message began by talking about the transition of the coronavirus-19 from pandemic to endemic status. With the mass vaccinations behind us, that seems to be the case. I now know many people from the IAEE family, including myself as of a couple of weeks ago, who have contracted the disease after having been vaccinated usually at least three times. The universal experience in this group is that the disease manifests as somewhere between a severe cold and a mild influenza. Countries and airlines appear to be getting more relaxed about infections and are loosening the many restrictions they had in place. From the perspective of IAEE activities, I hope that this means we can get back to our usual order of business with regard to face to face conferences.

The second issue I mentioned in the last Energy Forum message was the resurgence of energy security as an issue. That surely has continued to be the case. It means that we all have lots to talk about at our conferences! I hope that the need to discuss this issue with other energy professionals serves as a motivator for you all to take advantage of the many opportunities IAEE is making available in the next six months.

We have four major conferences for the remainder of 2022 and one more planned for early February 2023. First is the 2022 International Conference taking place in Tokyo from July 31 through August 3. Our Japanese hosts have planned a very exciting program and we already have a great line-up of speakers and presentations. It looks like the Japanese Government may also be relaxing travel restrictions in time for the conference, so please make your plans to join us there!

The international conference will be followed by the 17th IAEE European Conference to be held in Athens from September 21-24. Once again, we have had a fantastic response from prospective conferees. No doubt the continuing fallout for European energy markets from the Russian invasion of Ukraine will be a hot topic for discussion, as will alternative sources of energy imports into Western Europe and the links between energy supply, energy security and national security issues. Please make your plans to join us there.

The USAEE/IAEE North American conference will follow in October 24-26. It is going to be held at the Omni Hotel in the Galleria precinct of Houston. We have some great student events planned, including a poster competition and a PhD day to be held on the campus of Rice University. The Houston chapter of the USAEE has resumed its face-to-face activities, so we are hopeful of seeing a strong local contingent at the conference. There will be plenty of issues to discuss, including shale oil in West Texas, the continued development of LNG exports out of the Gulf Coast region, the continued growth of wind and now solar generation in Texas,

(continued on page 2)

President's Message (continued)

and ongoing discussions about electricity market structure reforms in the wake of the "big freeze" in Texas in February 2021.

The following month, the 8th ALADEE Conference will be held from November 20-22 in Bogota, Colombia. No doubt there will be discussions about the extent to which South American countries may be able to make up for the shortfall of oil exports from Russia. There is the ongoing story of offshore developments in Brazil, joined now by Guyana. There is also interest in when the Venezuela reserves might again support substantial oil exports, while hydrocarbon developments in Colombia, Ecuador, Peru, Bolivia and Argentina are other perennial topics of conversation. They will be joined this year by discussions of renewable energy and energy minerals developments, including discussions about developing a hydrogen export industry out of Chile.

Last, but by no means least, the 2023 International Conference will be in Riyadh, Saudi Arabia, from February 4–9. Once again, planning for the conference is well underway and it is shaping up to be an event of major importance to IAEE. We hope to see many new members from Africa and South Asia join our strong Middle Eastern and European contingents. Discussions will touch on matters of critical importance for future developments in both the demand and supply sides of the world energy industry.

Please visit https://www.iaee.org/en/conferences/ for the latest information on all these conferences. You can also find the Call for Papers notices on our web site.

Let me end by discussing the Association Management Company (AMC) transition process. The AMC Vetting Committee will soon be choosing the finalists from our RFP process. These firms will be invited to send representatives to the Tokyo conference where IAEE Council will meet with them in person and select the company we will contract with for services from January 2023. We are extremely grateful to Christophe Bonnery for chairing the AMC Vetting Committee and for all the fantastic help that AMS has provided to us throughout this process.

Peter Hartley

Careers, Energy Education and Scholarships Online Databases

IAEE is pleased to highlight our online careers database, with special focus on graduate positions. Please visit http://www.iaee.org/en/students/student_careers.asp for a listing of employment opportunities.

Employers are invited to use this database, at no cost, to advertise their graduate, senior graduate or seasoned professional positions to the IAEE membership and visitors to the IAEE website seeking employment assistance.

The IAEE is also pleased to highlight the Energy Economics Education database available at http://www.iaee.org/en/students/eee.aspx Members from academia are kindly invited to list, at no cost, graduate, postgraduate and research programs as well as their university and research centers in this online database. For students and interested individuals looking to enhance their knowledge within the field of energy and economics, this is a valuable database to reference.

Further, IAEE has also launched a Scholarship Database, open at no cost to different grants and scholarship providers in Energy Economics and related fields. This is available at http://www.iaee.org/en/students/ListScholarships.aspx.

We look forward to your participation in these new initiatives.

Editor's Notes

We conclude our focus on research on COP26 and Climate Change, continued from the second quarter 2022 issue. We are most grateful for the enthusiastic reader response on this topic.

Richard Green and **Iain Staffell** show how Shapley values can disentangle the influence of various overlapping and interlapping policies on national reductions in CO2 emissions.

Lin Zhang discusses the challenges and opportunities on Hong Kong's strategies for combating climate change in four sectors including power generation, building, waste management, and finance. We highlight the importance of improving its climate change mitigation capacity through regional collaboration.

Ganesh Doluweera, **Matthew Hansen**, and **Bryce van Sluys** explore alternative scenarios to achieve net-zero emissions in Canada's electricity sector. Those scenarios reveal technological pathways for deep-decarbonized electricity supply under increased demand due to electrification.

Dina Azhgaliyeva and **Zhanna Kapsalyamova** use global data from Bloomberg over the period 2017-2021 to provide a review of issuance and policies promoting Green sukuk, a Shari'ah-compliant financial instrument that is designed to fund environmentally friendly projects.

Livingstone Senyonga provides a recap of the successful launch of the Uganda Association for Energy Economics. A variety of lectures and discussions highlighted the vision of this new affiliate of the IAEE. Also included is a collage of pictures taken at the event.

Gautam Swami asks, "Will finance and technology rise jointly to the emerging challenges and opportunities?"

John Holding reviews the history of the global efforts to counteract climate change under the auspices of the UN and how these efforts have evolved and shifted over time. Looking forwards, a reality check regarding fossil fuel use plus the opportunity for carbon dioxide removal techniques will be explored.

Stefan Gahrens, **Beatrice Petrovich**, **Rolf Wüstenhagen**, and **Alessandra Motz** state that electric vehicles can significantly contribute to decarbonizing transport – but does that really matter to consumers? Based on a survey in Switzerland, one of the fast-growing European EV markets, we find that moving closer to the purchase decision the share of well-informed adopters increases, but their climate optimism decreases

Scott Linn and **Zhen Zhu** have written an article on an issue in regulated utility cost of capital. This issue often comes up in utility cost of capital filings at the state levels even though the FERC does not address this directly.

Masao Tsujimoto explores environment conservation with development of digital platforms, employing financial performance and environmental impact data from six digital platform providers in the US and Japan.

DLW

IAEE MISSION STATEMENT

IAEE's mission is to enhance and disseminate knowledge that furthers understanding of energy economics and informs best policies and practices in the utilization of energy sources.

We facilitate

- **Worldwide information flow and exchange of ideas on energy issues**
- **High quality research**
- **Development and education of students and energy professionals**

We accomplish this through

- **Leading edge publications and electronic media**
- **International and regional conferences**
- **Networking among energy-concerned professionals**

43rd IAEE INTERNATIONAL CONFERENCE

Plenary Program and Registration Announcement

31 July - 4 August 2022

Mapping the Energy Future -Voyage in Uncharted Territory-

JAPAN BORDER IS OPENING UP

On 26th May, Japan's Prime Minister, Mr. Kishida has announced that Japan will relax its COVID special border control from 10 June. Already, many rules have been relaxed. Please check our website.

UPDATE ON REGISTRATION

Over 400 people have registered for the Conference!
Nearly **two thirds** of participants will join the Conference **in-person**. Don't miss the chance to visit Tokyo and exchange views with wonderful experts from all around the world.
IAEE2022 allows you to choose your best participation mode: **in-person or virtually**.
When you decide to come to Tokyo, please read "Important Notice to enter Japan for IAEE 2022" on our website and be sure to check the website of the Japanese Embassy or Consulate-General in your area of residence for the latest information.

HOW TO REGISTER FOR THE CONFERENCE

Visit our website and check details on registration types and fees here.
When you are ready, please click the "Online Registration Form" button to proceed to the registration site.

HOW TO MAKE HOTEL RESERVATIONS

IAEE2022 will be held as a hybrid conference. If you will join us in person, please check our website for your accommodation.
JTB Global Marketing & Travel Inc. (JTBGMT) is the official travel agent for IAEE2022 and will handle accommodation.
JTBGMT has blocked rooms at hotels of walking distance from venue.
Please make your application for booking via "Reservation Form" here.

Organizers of 43rd IAEE International Conference

IAEE International Association for Energy Economics — IEE JAPAN — GRIPS 政策研究大学院大学 National Graduate Institute for Policy Studies

43rd IAEE INTERNATIONAL CONFERENCE

Plenary Program and Registration Announcement

31 July - 4 August 2022 JAPAN, TOKYO
Mapping the Energy Future -Voyage in Uncharted Territory-

PLENARY SESSION PROGRAM

Tokyo is getting ready to host the 43rd IAEE International Conference in 31 July-4 August 2022. The most recognizable names of the energy sector will enrich the Conference's Plenary Sessions – 2 Plenary Sessions and 8 Dual Plenary Sessions. Get a glimpse of the up-to-now confirmed plenary speakers, join the Conference and get inspired by the most influential thought-leaders, high-ranking officials and game-changing heads from non-governmental organizations.
For more information, please visit our website.

Opening Plenary	**Hoesung Lee**, IPCC Chair (in-person) **Marianne Laigneau**, Chairman of the Management Board, ENEDIS (in-person) And more to come…

Dual Plenary 1: Energy Geopolitics

- **Ken Koyama**, IEEJ
- **Jun Nishizawa**, Mitsubishi Corporation
- **Keisuke Sadamori**, IEA
- **Paul Stevens**, Chatham House
- **Tatiana Mitrova**, Oxford Institute for Energy Studies

Dual Plenary 2: Climate Change

- **Nan Zhou**, Lawrence Berkeley National Laboratory
- **Fumihiko Ito**, Sumitomo Mitsui Banking Corporation
- **Yuzo Yoshida**, Idemitsu Kosan Co., Ltd.
- **Akshima Ghate**, Rocky Mountain Institute, India
- **Noura Mansouri**, KAPSRAC

Dual Plenary 3: Hydrogen Society

- **Kazunari Sasaki**, Kyushu University
- **Shiota Tomoo**, ENEOS
- **Mansur Zhakupov**, TotalEnergies
- **Yoshihiko Hamamura**, Toyota Motor Corporation

Dual Plenary 4: Clean, Affordable and Accessible Energy for All

- **Roula Inglesi-Lotz**, University of Pretoria
- **Rebecca Bregant**, Pineberry / Alliance for Rural Electrification
- **Anne McDonald**, Sophia University

Dual Plenary 5: Future Role of Fossil Fuels

- **Nobuo Tanaka**, Former Executive Director, IEA
- **Takeshi Matsui**, The Japan Gas Association
- **Hamid M. Al Sadoon**, KAPSARC
- **Lucian Pugliaresi**, EPRINC

Dual Plenary 6: Global Energy Transition

- **Peter Hartley**, Rice University
- **Kimihisa Kittaka**, INPEX Corporation
- **Anna Collyer**, Australian Energy Market Commission
- **Robert Feldman**, Morgan Stanley MUFG Securities Co., Ltd. / Tokyo University of Science
- **Thomas-Olivier Léautier**, Toulouse School of Economics / TotalEnergies

Dual Plenary 7 : Nuclear Energy

- **Yasumasa Fujii**, The University of Tokyo
- **Warren McKenzie**, HB11 Energy Pty Ltd
- **Robert F. Ichord**, Atlantic Council

Dual Plenary 8: Future of Mobility

- **Ali Izadi-Najafabadi**, Bloomberg NEF
- **Ashok Sarkar**, World Bank
- **Andianto Hadayat**, Pertamina
- **Kengo Nishimura**, Uber Japan

Organizers of 43rd IAEE International Conference

IAEE International Association for ENERGY ECONOMICS

IEE JAPAN

GRIPS 政策研究大学院大学 National Graduate Institute for Policy Studies

Overlapping Policies and British Electricity Decarbonisation

BY RICHARD GREEN AND IAN STAFFELL

Richard Green is Professor of Sustainable Energy Business at Imperial College Business School, London, UK and can be reached at r.green@imperial.ac.uk. Iain Staffell is a Senior Lecturer in Sustainable Energy at Imperial College London, UK.

Abstract

Richard Green and Iain Staffell (Imperial College London) show how Shapley values can disentangle the influence of various overlapping and interlapping policies on national reductions in CO_2 emissions.

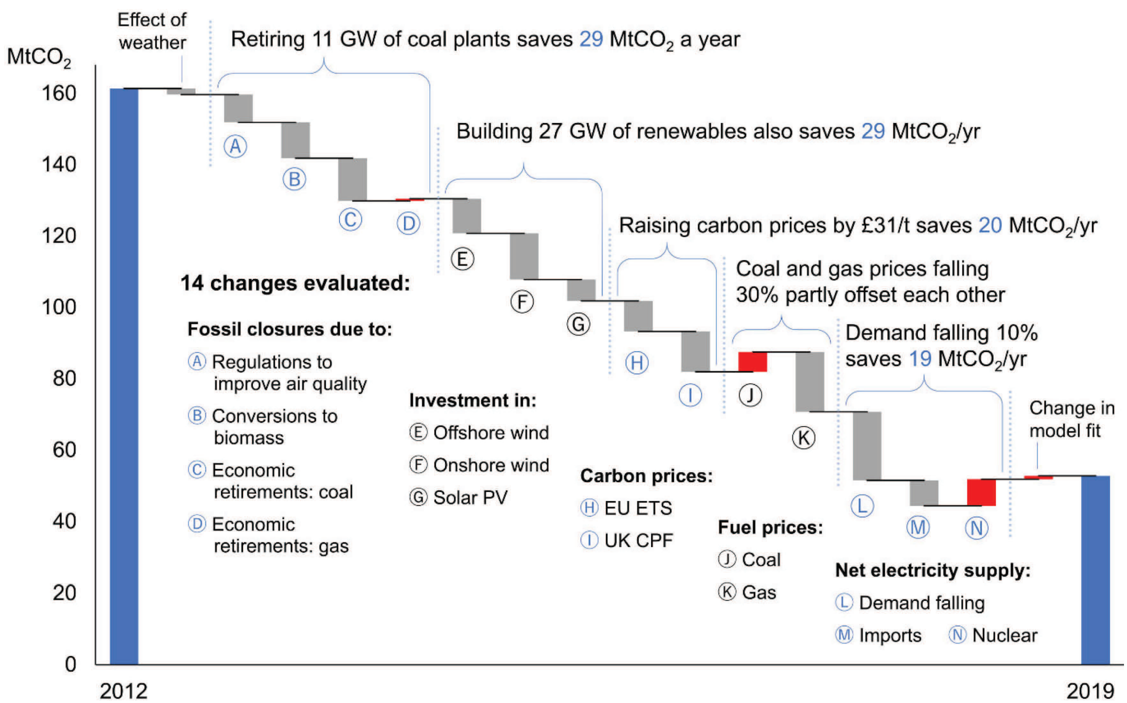
Carbon dioxide emissions from electricity generation in Great Britain fell by 66% between 2012 and 2019 – a faster decline than in any other country. The UK government adopted all the standard policy responses to a negative externality: taxes on emissions, regulations to limit the use of high-carbon technologies, and subsidies for clean alternatives. How much each of these actions contributed towards reducing overall carbon emissions has been difficult to assess, as they happened simultaneously, interacted with one another, and were muddied by exogenous effects such as changing fuel prices and the weather. This mirrors a wider problem facing governments: without a precise estimate of how much emissions a technology or policy will save (including its knock-on impacts and interactions with the rest of the system), it is not possible to estimate the carbon cost, the marginal abatement cost, or the appropriate level of support to offer.

We have used Shapley values to attribute emissions reductions between 14 separate changes to the British power system, including fuel and carbon prices, the capacity of various types of power station, and electricity demand. The Shapley value, a concept from cooperative game theory, allocates the benefits created by individual players when they come together in a coalition. In our context, the "players" are the changes we study, and the "benefits" are emissions reductions. A player's Shapley value is effectively the average of all their possible marginal contributions, considering every (ordered) permutation in which they could have joined the coalition. The sum of the players' values always equals the available benefits.

An economist's first instinct might be to calculate each player's marginal contribution by asking what happens if they were to withdraw from the (final) coalition, but this will generally either over- or under-allocate the available benefits. In the context of carbon emissions from electricity, the effect of closing coal plants (for example) added to that of (separately) raising carbon prices will differ from the effect of doing both simultaneously; the impact of renewable generation will depend on whether coal or gas stations are typically at the margin, and so on. Previous studies based on marginal impacts therefore have to include a residual for interaction effects, which the Shapley value avoids.

We employed a (fast) simulation of the British electricity system that finds the cost-optimal half-hourly generation mix between 2012 and 2019. We ran this some 16,384 times, to represent every possible combination of our fourteen changes either following its historic evolution or staying fixed at 2012 levels (except for weather variation, where relevant). The modelled changes in emissions were used to calculate the Shapley values shown below.

The blue bars at either end of this diagram show that actual emissions fell from 161 $MtCO_2$ in 2012 to 53 $MtCO_2$ in 2019. The first grey bar shows that the



Emmissions were 161 $MtCO_2$ in 2012 and fell to just 53 $MtCO_2$ in 2019 weather was slightly better in 2019 than in 2012 (it was warmer by 0.8°C), reducing the emissions that a counterfactual system would have produced in 2019. The last red bar shows that our model's fit to the real system only changed slightly over the period (an over-prediction of 1.8 $MtCO_2$ fell to one of 0.7 $MtCO_2$).

In between these are the 14 changes we simulated. The reduction in coal capacity (some of it converted to burn biomass) and the growth of wind and solar output both saved 29 Mt of CO_2 emissions in 2019, compared to 2012. The British carbon tax and the (relatively recent) increase in the EU ETS price saved 20 Mt, while falling demand saved 19 Mt. Increasing imports (measured as a pure saving on a UK territorial basis, and still a net saving when comparing British and continental emissions rates) almost exactly offset falling nuclear output in 2019. The lower price of gas relative to coal saved 11 Mt.

Our analysis is not strictly causal. Changes in European carbon and fuel prices (labelled H, J and K in the diagram) were largely exogenous to developments in the UK electricity market. Investments in renewable capacity (B and E-G) depended on UK government policies, which also set our carbon tax (I). Nuclear closures (N) were age-related, and those under the EU's Large Combustion Plant Directive (A) were committed to at a time when (some) generating companies were still considering new build coal in the UK; the stations closed were old and flue gas desulphurisation retrofits uneconomic.

On the other hand, the post-2015 retirements of coal and gas plant (C and D) were affected by carbon prices and renewable capacity, and electricity demand (L) responded to prices (albeit inelastically) as well as to increasing energy efficiency. Imports (M) were also affected by electricity prices, though some of the factors affecting Britain were also relevant in neighbouring countries. We hope to reduce the importance of these caveats with further research, such as by making demand in the model price-sensitive.

We believe that this technique offers a robust way to estimate the 'value' of individual technologies or actions for decarbonisation, accounting for the complex interactions they have upon one another.

A full account of this research is available in Green, R.J. and I. Staffell (2021) "The Contribution of Taxes, Subsidies and Regulations to British Electricity Decarbonisation", *Joule*, vol. 5, no. 10, pp.2625-45, https://doi.org/10.1016/j.joule.2021.09.011

Hong Kong's Fight for Climate Change: Facts, Challenges, and Opportunities

BY LIN ZHANG

Abstract

In this article, we discuss the challenges and opportunities on Hong Kong's strategies for combating climate change in four sectors including power generation, building, waste management, and finance. We highlight the importance of improving its climate change mitigation capacity through regional collaboration.

Hong Kong is a coastal city on the eastern Pearl River Delta in China. With a population density of 6,754.04 people per square kilometre in 2020, Hong Kong is one of the most densely populated cities in the world. Typhoons occur quite often, which sometimes result in floods or landslides. According to the report of Hong Kong Observatory, there were 222 tropical cyclones during the period of 1980-2018. What's more, the numbers of tropical storms and typhoons with No. 8 warning signals are increasing over the past decade, which evidences the intensified consequences of climate change in Hong Kong (Zhou & Zhang, 2021).

To mitigate climate change and the emissions of greenhouse gases, Hong Kong has set an ambitious target of reducing carbon intensity by up to 70% by 2030 from 2005 level and has committed to be carbon neutral by 2050 through its Climate Action Plan 2050 announced on October 8th, 2021. It outlines the strategies and targets for combating climate change and achieving carbon neutrality in four sectors including power generation, building, transport, and waste management.

Climate change induces water scarcity, the remaining intermittent concerns of green energy, could slow down the transition towards renewable energy (An & Zhang, 2021). However, we are confident in Hong Kong's energy future. One of the four major decarbonization strategies in Hong Kong's Climate Action Plan 2050 is to achieve net-zero electricity generation before 2050. CLP, one of the two utility providers in Hong Kong, has taken substantial efforts in mitigating its environmental impacts. Through a joint venture between the Guangdong Nuclear Investment Co. Ltd and CLP, it can provide carbon-free electricity to customers in Hong Kong, accounting for over 20% of the total electricity supply in Hong Kong. Another initiative on climate change mitigation is the Renewable Energy Certificates (RECs), which offer a simple and flexible option for its customers to support clean energy generation. We believe that the power section in Hong Kong has long been ready for the low-carbon transition.

In the past four decades, Hong Kong has seen its constant increase in the electricity consumption, where consumption by buildings accounts for about two thirds of the total. Among all the electricity consumption sources, residential and commercial buildings have been the top two end consumers which accounts for 64% and 26% respectively of the total building electricity end-use in Hong Kong in 2016 (Sheng et al., 2020). This makes buildings particularly require attentions in Hong Kong. Hong Kong utilizes the Overall Thermal Transfer Value (OTTV), which is an index explaining the overall heat transfer rate through building envelope, to control building energy consumption. However, according to Sheng et al. (2020), current OTTV regulation practice cannot help Hong Kong to achieve its reduction target in 2030. Entirely relying on stricter OTTV legislations makes it difficult to meet the goal of reducing to 70% of the building electricity consumption in the 2005 level. More efficient policy strategies would be required to offset electricity consumption increase.

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Waste management is also an important aspect for the successful curbing emissions and environmental pollutions. In 2020, the daily disposal of MSW at landfills has reached 1.44 kg/person, ranked 4th in the East Asia and Pacific regions. According to the Environmental Protection Department of Hong Kong's 2019 report, Hong Kong generated 5.67 million tonnes of MSW in 2019; 29% of the MSW was recovered, while the rest was disposed of in landfills. There are three landfill plants in service in Hong Kong. However, according to the waste hierarchy, waste should always be reduced, reused, and recycled before moving to the stage of recovery and disposal. Waste reduction and recycling should remain important considerations in a city's waste management. It is encouraging that the Hong Kong Legislative Council recently passed the city's first and long-awaited waste disposal bill, 16 years after it was first proposed. The proposed Hong Kong Waste Charging Scheme requires its residents to pay a tax on the garbage they generate, in line with the "polluter-pays" principle where charges are based on the quantity of waste generated. This is, however, only the first step, advances in environmental education and users' participation are necessary, as these are the critical factors affecting the effectiveness of the waste management system.

As the financial centre in the region of Asian Pacific region, the business sector has long tradition of incorporating environmental sustainability into strategy. HK can further extend its impact through the one belt one road initiative. Most projects in the Belt and Road initiative are for infrastructure construction, which can have a strong impact on the environment. In 2020, China's overseas investment on wind, solar and hydropower overtook that on coal and other fossil fuels for the first time since the launch of the Belt and Road Initiative. Hong Kong could utilize its financial role to promote green finance and investment.

Corporations have taken actions in responses to the call for reporting climate-related financial risks advised by the task forces of The Financial Stability Board, the so-call TCFD reporting. In fact, firms and financial sectors in HK have rich experience on such sustainability related disclosure. Hong Kong's Securities and Futures Commission (SFC) has issued new guidelines on enhanced disclosures required for Hong Kong-authorised funds incorporating environmental, social and governance factors as their key investment focus (ESG funds). Meanwhile, the government must improve information statistics and data disclosure across all asset classes and financial services data shall be provided to support for green financial policy evaluation publicly.

There are still plenty of room for Hong Kong to further improve its capacity in climate change mitigation. It has been hotly debated that regional collaboration within the Greater Bay Area (GBA) of China is the key for Hong Kong's success in its transition towards carbon neutrality. With a population of over 67 million, GDP in the GBA region reaches 1000 billion USD, higher than that of New York metropolitan area. As the national long-term strategies, the deep integration of the Greater Bay Area Initiative and the Belt and Road Initiative will lead the GBA to be better integrated in terms of collaboration and know-how exchange, to promote the region's capacity in fighting for climate change.

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Hellenic Association for Energy Economics - www.haee.gr

The upcoming 17th IAEE European Energy Conference will seek to enrich the dialogue on some of the most crucial issues facing the energy community, as the world struggles to heal the wounds induced by the Covid-19 and the ongoing war in Ukraine.

With an exquisite line-up of speakers covering the full spectrum of energy economics, Conference delegates will get the chance to deep-dive into discussions of the most pressing challenges, such as the sky-high energy prices, environmental regulations and broken supply chains, making Athens' Conference a must-attend event for government officials and regulators, thought leaders, industry heads, analysts and academics.

Make sure to register on time and benefit from our early bird registration fees.

Register

Visit the Conference website to check more details on:

- the list of up-to-now confirmed speakers who are invited to deliver the most prime content

- the draft program outline, summarizing the 4-day activities

- the social and cultural events, enriching our program, and offering plenty of chance for networking

- accommodation options for the Conference delegates with reduced rates, and many more

See you all in Athens!

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The Path Towards Net-Zero Greenhouse Gas Emissions in Canada's Electricity Sector

BY GANESH DOLUWEERA, MATTHEW HANSEN, AND BRYCE VAN SLUYS

The authors are with the Canada Energy Regulator (CER). Ganesh Doluweera and Matthew Hansen are Technical Leaders, and Bryce van Sluys is the Director of the Energy Outlook Team of the CER. Ganesh Doluweera may be reached at ganesh.doluweera@cer-rec.gc.ca.

Abstract

This article explores alternative scenarios to achieve net-zero emissions in Canada's electricity sector. Those scenarios reveal technological pathways for deep-decarbonized electricity supply under increased demand due to electrification.

Introduction

As a signatory to the 2015 Paris Agreement, Canada is committed to achieving net-zero greenhouse gas (GHG) emissions by 2050. Canada has set targets to reduce the country's GHG emissions by 40-45% below 2005 levels by 2030 and to achieve net-zero GHG emissions by 2050 (Government of Canada, 2022). Over 82% of Canada's GHG emissions are from energy producing and consuming processes. Transformational changes are required in how Canadians produce and consume energy to achieve net-zero emissions by 2050. The electricity sector is at the forefront of Canada's efforts to achieve net-zero emissions by 2050. Canada's federal, provincial, and territorial governments have implemented many programs and policies to reduce GHG emissions from the electricity sector and to electrify end-use energy services. The Canadian federal government is envisioning to achieve a 100% net-zero electricity system by 2035 (CER, 2021; Government of Canada, 2022).

In pursuit of net-zero emissions, the electricity sector in Canada has an early advantage. About 82% of Canada's electricity already comes from non-GHG emitting sources such as hydro, nuclear power, wind, and solar (CER, 2021). This share has been growing, and emissions associated with the remaining generation have declined significantly over the past two decades. The GHG emissions intensity of Canada's electricity generation has declined by 45%, from 220 grams CO_2 equivalent (gCO_2e)/kWh in 2005 to 120 gCO_2e/kWh in 2019 (ECCC, 2021).

Despite the cleaner generation base, there are uncertainties in the path forward to achieve net-zero emissions in Canada's electricity sector. Several Canadian provinces currently have fossil fuel dominated generation fleets. In all provinces, including those with a lower emission generation fleet, achieving net-zero emissions while satisfying increased electricity demand due to electrification of end-use energy services can be challenging.

This article explores six scenarios that explore pathways to achieving net-zero emissions in Canada's electricity sector. The six scenarios are developed in *Canada's Energy Future 2021* report, which is the most recent installment of the Canada Energy Regulator's (CER's) long-term energy supply and demand projections (CER, 2021).

Net-Zero Electricity Scenarios for Canada

The six net-zero electricity scenarios are developed based on the primary energy supply and demand scenario of Canada's Energy Future 2021, which is called the Evolving Policies Scenario (EPS). The central premise of EPS is that action to reduce the GHG intensity of our energy system continues to increase at a pace similar to recent history in both Canada and the world. The EPS implies lower global demand for fossil fuels and greater adoption of low-carbon technologies than a scenario with less action to reduce GHG emissions. The EPS assumes a significant level of electrification for many end-use energy services. For example, in EPS, significant uptake of passenger electric vehicles leads to a 17% electricity demand increase by 2050 compared to the current total electricity demand. Similarly, the electricity demand in the residential sector increases by about 22% by 2050, where a key driver is the adaptation of heat pumps for space heating. The overall electricity demand grows by 44% by 2050, compared to current levels.

The net-zero electricity (NZE) scenarios assume more stringent climate action in the form of a higher carbon price than the EPS. The expected result is that a sufficiently high carbon price will drive the electricity sector towards net-zero emissions. Furthermore, the NZE scenarios assume a higher electricity demand level in Canada than the EPS to capture an increased level of energy end-use electrification consistent with expectations of a net-zero future. Given the uncertainty around the costs and viability of different low-carbon technologies, there are many potential pathways to achieve a net-zero electricity system. The six NZE scenarios explore those uncertainties. The main NZE scenario explored here is called the NZE Base scenario. Starting from NZE Base, five other alternative scenarios are developed by varying key inputs such as demand, carbon prices, and technology availability. The premise and main characteristics of the NZE Base and other alternative scenarios are presented in Table 1. A core set of assumptions, including technology costs, fuel prices, and hourly demand profile shapes, were held constant across scenarios.

Under each of the six NZE scenarios, the operations of electricity systems of all ten Canadian provincesare assessed using the hourly electricity module of the

Table 1: Premise and Characterizing Features of Net-Zero Electricity Scenarios

Scenario	Scenario Rationale	Allowable Capacity Expansions	Other Features
NZE Base	Continually increasing Canadian climate policies may lead to a higher carbon price and a higher level of end-use energy demand electrification than the assumptions made in the Evolving Policies scenario.	Generation technologies: natural gas fired combined cycle, natural gas fired simple cycle, and natural gas fired combined cycle with carbon capture and storage (CCS)* units, wind, solar, hydro, conventional nuclear, and SMR Electricity storage Inter-provincial transmission	Electricity demand is 10-30% higher than the Evolving Policies Scenario, depending on the province. Carbon pricing is higher than the Evolving Policies Scenario, reaching $2020 300/ tonne(t) CO2 by 2050
Higher Carbon Price	It is plausible that more aggressive climate action is needed to drive the energy systems towards net-zero, leading to a higher carbon price than the value assumed in the NZE Base scenario.	Same as NZE Base	Same electricity demand as Base Carbon pricing reaches $2020 800/ tCO2 by 2050.
Higher Demand	A higher level of electrification is possible due to uncertainty around specific climate action and technology development.	Same as NZE Base	Electricity demand is 15-45% higher than the Evolving Policies Scenario, depending on the province. Same carbon pricing as NZE Base.
Limited Transmission	Interprovincial transmission expansion is costly, and the timing of investments is uncertain. Therefore, new interprovincial transmission development may not be feasible.	Same as NZE Base, but no new inter-provincial transmission is allowed.	Same electricity demand and carbon pricing as NZE Base
Hydrogen	There is a high level of interest in hydrogen as a technology path to decarbonize the economy. Accordingly, there is the possibility of low-cost low/zero carbon hydrogen being available for electricity generation.	All NZE Base options and hydrogen fired generation technologies.	Same electricity demand and carbon pricing as NZE Base
BECCS	Negative emissions technologies feature prominently in previous net-zero scenarios. Within that scope, biomass-fired electricity generation with CCS is attractive as it simultaneously produces electricity and removes carbon dioxide from the atmosphere. Therefore, it is plausible that biomass-fired electricity generation with CCS is available in the near future.	All NZE Base options and biomass CCS* generation technology.	Same electricity demand and carbon pricing as NZE Base

*CCS technologies, including natural gas with CCS and BECCS, are only allowed to be built in the provinces of Alberta and Saskatchewan due to the greater availability of proven geological potential to store CO2 and availability of active CCS projects.

CER's Energy Futures Modeling System. The hourly electricity module optimizes the provincial electricity systems' operations at one-hour intervals and expands the generation system as needed. Interprovincial electricity trade is also modelled. Under the particular scenario assumptions, the main objective is to construct and operate an optimal generating unit fleet that would minimize the total cost of satisfying electricity demand in a given Canadian province. The scenario assessment was conducted for the period 2030-2050. The scenario assessment discussed in this article does not force the electricity sector to be purely non-emitting in any year. Rather, carbon pricing is served as a proxy for the cost of carbon removal and potential technology options to determine the ultimate carbon emissions of the electricity sector.

This article presents the results for 2030 and 2050, the two years for which Canada has set major emission reduction targets. Furthermore, the results presented here are aggregated across the provinces.

Electricity Supply in Net-Zero Electricity Scenarios

Figure 1 shows installed capacity by technology in different scenarios. In the NZE Base scenario, non-emitting generation technologies (i.e., hydro, nuclear, solar, and wind) and electricity storage account for 80% of the installed generation capacity in 2030. By 2050 that share increases to 89%. At a combined capacity of 134 GW, which is about 41% of the installed capacity, solar and wind dominate the electricity generation fleet in 2050. Compared to the current levels, wind capacity doubles by 2030 and is five times greater by 2050. Compared to the current levels, the solar capacity is twenty times larger by 2050. Electricity storage is installed to facilitate the operations of variable renewables and support grid operations. New hydropower capacity additions are relatively small and only see a cumulative new capacity addition of about 4.2GW in the period 2030 - 2050, a 5% increase from current levels. Similarly, the growth of nuclear power is also comparatively small. All new nuclear additions are through small modular reactor (SMR) technology. About 6.6 GW of SMR units are added by 2050. In combination,

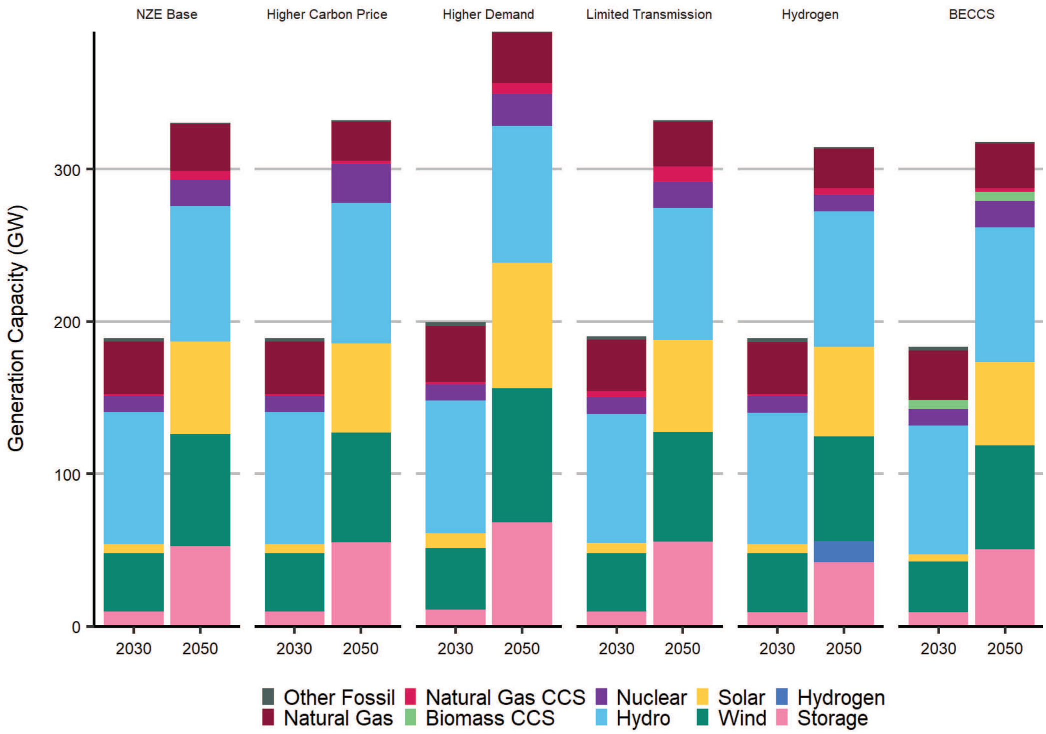

Figure 1: Installed Capacity by Technology in Different Scenarios

hydropower and nuclear represent 5% of new capacity additions. Low-emitting natural gas CCS units are built in the provinces of Alberta and Saskatchewan, where CO2 storage is known to be available. In the Base NZE scenario, 5.6 GW of natural gas CCS units are added by 2050. In the Base NZE scenario, fossil fuel-based technologies, mainly natural gas units, represent approximately 20% of total generating capacity in 2030 and decline to 11% by 2050. Natural gas unit additions are dominated by simple cycle gas turbines that primarily provide grid balancing.

Figure 2 shows the amount of electricity generation by technology in different scenarios. In the NZE Base scenario, non-emitting generation (e.g., hydro, nuclear, solar, and wind) produces 93% of electricity in 2030 and 97% in 2050. Overall, by 2030 94% of electricity is generated by low- and non-emitting technologies (renewables, nuclear, and CCS-enabled fossil fuel), rising to 99% in 2050. Hydropower and nuclear power provide the largest share of the electricity supply in both periods. However, the amount of electricity provided by those two technologies remains relatively unchanged from 2019 levels, at roughly 50 TWh throughout the projection period. New demand growth is primarily satisfied by wind and solar.

The current share of fossil fuel-based electricity generation is 19%, and that decreases over the projection period, reaching 3% of the electricity supply by 2050. By the end of the projection period, about two-thirds of the fossil fuel fired generation comes from natural gas units equipped with CCS technology. The remainder consists of natural gas simple cycle units that provide some grid balancing services to maintain system reliability.

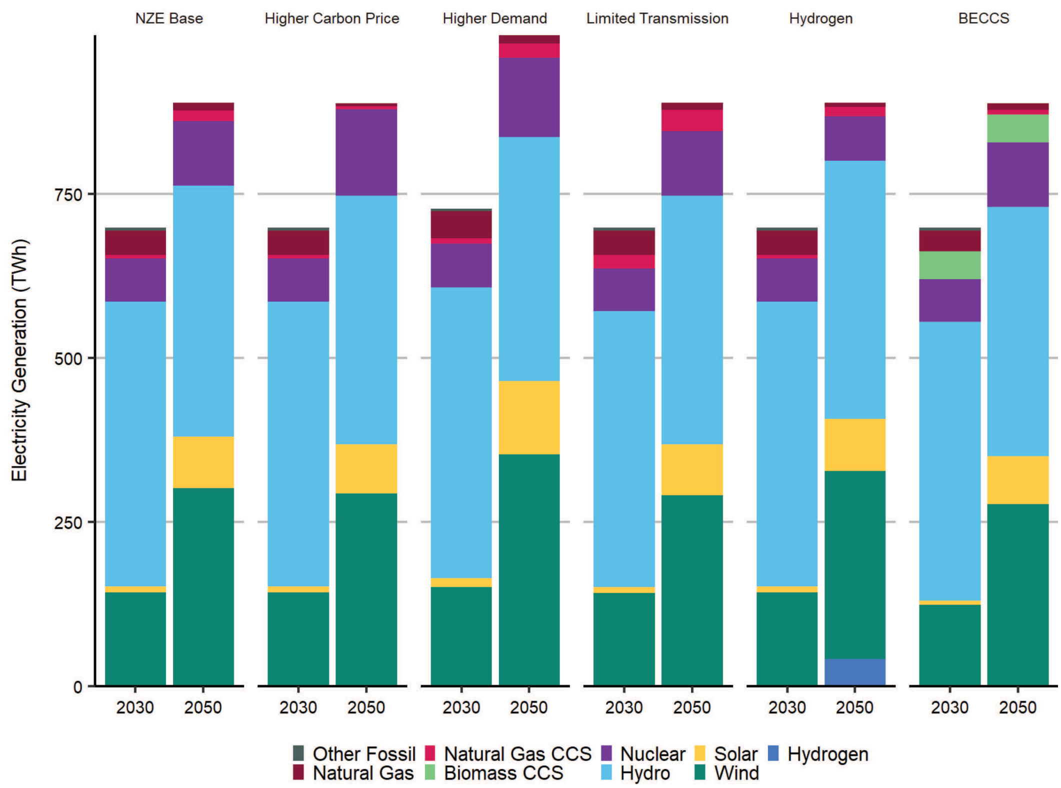

Figure 2: Electricity Generation by Technology in Different Scenarios

Installed capacity and generation in the other five scenarios are similar to those of the NZE Base scenario, with some noteworthy observations.

The Higher Carbon Price scenario sees reductions in capacity and electricity generation by natural gas units in 2050 compared to the NZE Base scenario. Cumulative new natural gas capacity additions are 30% lower than NZE Base by 2050. Compared to NZE Base, natural gas-fired generation is 60% lower in 2050. Due to the residual CO_2 emissions that are not captured by the CCS process (10% of the combustion emissions), natural gas CCS is also impacted by the higher carbon price. That makes natural gas CCS less competitive. Compared to NZE Base, natural gas CCS cumulative capacity additions are 60% lower, and electricity generation is 70% lower. The reductions in natural gas fired generation capacity are offset by increased hydropower and nuclear SMR.

The Higher Demand scenario assumes a higher level of electrification and, therefore, about 12% higher electricity demand overall in 2050. In 2050, the higher electricity demand in this scenario is satisfied by increased solar (+ 33 TWh), wind (+51 TWh), nuclear (+23 TWh), and natural gas CCS (+5 TWh) generation compared to NZE Base.

The Limited Transmission scenario only sees notable changes in the four western provinces. In the NZE Base scenario the hydropower resources in British Columbia and Manitoba partially provide system flexibility to manage variable wind and solar power supply in the neighbouring provinces of Alberta and Saskatchewan. This process is facilitated by the addition of new inter-provincial transmission capacity. The Limited Transmission scenario inhibits new transmission capacity additions, and consequently, the combined wind and solar power generation decline by about 5% relative to NZE Base. That reduction in the electricity generation is filled by a higher level of natural gas CCS units. The Limited Transmission scenario sees a doubling of natural gas CCS capacity and generation compared to NZE Base.

The Hydrogen scenario assumes the existence of a relatively mature market for hydrogen in Canada, where hydrogen production costs through electrolysis and natural gas with CCS have fallen significantly. Under the assumed conditions, hydrogen technologies have lower overall economic costs than all natural gas technologies. Consequently, the Hydrogen scenario sees a 25% reduction of non-CCS natural gas capacity (i.e., combined cycle and simple cycle) compared to NZE Base in 2050. Furthermore, the GHG emissions intensity of some hydrogen technologies is lower than that of natural gas CCS. Therefore, natural gas CCS sees a 20% capacity reduction in 2050 compared to NZE Base. The Hydrogen scenario also sees a 10% reduction in wind and solar capacity relative to NZE Base in 2050. The overall economics of the use of hydrogen for electricity supply is more favourable than building wind, solar and the additional flexible capacity they necessitate to balance supply and demand.

The BECCS scenario assumes the availability of biomass CCS units for electricity generation in the provinces Alberta and Saskatchewan. Biomass CCS is considered to have negative GHG emissions, and it is assumed that the technology would get credit for carbon removal from the atmosphere. The credit is assumed to be calculated using the full carbon price. As the carbon price increases, biomass CCS units become a negative cost generation option, where its average cost of production in 2050 is -$85/MWh. Therefore, biomass CCS partially displaces all other generation technologies in Alberta and Saskatchewan. Relative to NZE Base, the resulting reduction in natural gas CCS generation in 2050 is 56%, and that of combined wind and solar is about 15%. The cumulative biomass CCS capacity addition by 2050 is 6 GW, the maximum possible biomass CCS capacity due to the limitations in available biomass resources. At higher carbon prices, it may be economically competitive to import biomass for electricity production from other regions into Alberta and Saskatchewan, where suitable carbon storage is known to exist.

GHG Emissions Intensity of Electricity Sector in Canada

Figure 3 shows the GHG emissions intensity of the electricity sector in Canada in 2030 and 2050 in all scenarios we considered, compared to 2005 and 2019 levels.

In all scenarios, except the BECCS scenario, the GHG emissions intensity of Canada's electricity sector reaches about 27gCO_2/kWh in 2030. The value is 78% lower than the electricity sector emissions intensity in 2019. The emissions intensity further reduces in 2050 but varies across scenarios. The NZE Base scenario emissions intensity in 2050 is 8gCO_2/kWh, a 93% reduction compared to the emissions intensity in 2005. The

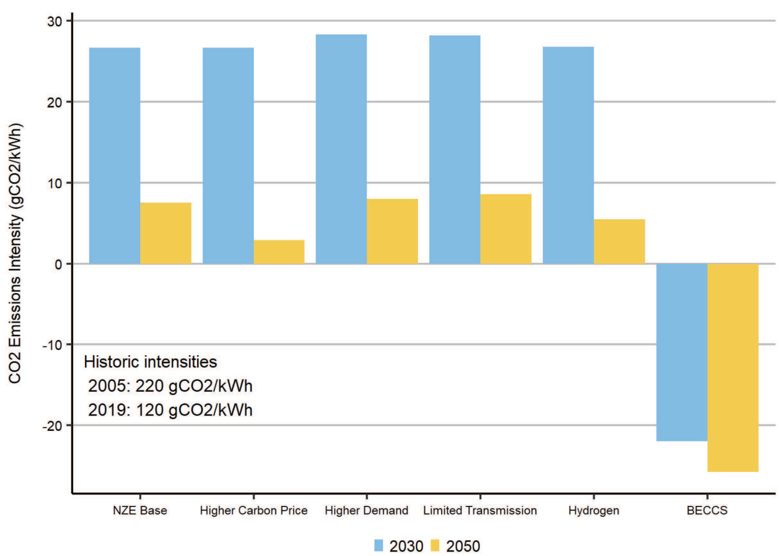

Figure 3: GHG Emissions Intensity of the Electricity Sector in Canada in Different Scenarios

Higher Carbon Price scenario sees the 2050 emissions intensity declining to $3gCO_2$/kWh.

While significant emissions reductions are achieved, none of the scenarios, except BECCS, see the overall electricity sector reaching net-zero. In those five scenarios, the emissions from the electricity sector drop dramatically, but a very small amount of emissions remains. Almost all of the remaining emissions come from natural gas-fired conventional units, which generate electricity infrequently, and uncaptured emissions from natural gas CCS units. Despite the increased cost due to carbon pricing, the electricity system analysis module allows those emissions because the value of those generating units in terms of electricity system reliability is high. This allowance reflects that, in the context of a broader net-zero world, the use of carbon removal options could potentially provide more cost-effective options than reducing those last few emissions from the electricity system in 2050.

The BECCS scenario sees the emissions intensity of the electricity sector going net-negative through carbon removal by the biomass CCS units. That would provide some emissions allowances for other economic sectors in Canada's path towards a net-zero future.

Conclusion

The electricity sector could play a pivotal role in achieving net-zero emissions in Canada both by reducing emissions from generating electricity and by reducing emissions in other sectors through electrification. The scenario analysis discussed in this article shows that there are many technological pathways to achieve significant emission reductions in the electricity sector. The majority of technologies required are available today, and Canadian electric utilities have experience in building and operating them. In Canada's pathway towards a net-zero future, the country's electricity sector will have multiple roles, including the supply of energy and potentially carbon removal through investing in negative emissions technologies.

Footnotes

[1] The electricity systems of the three northern territories of Canada are excluded from this analysis.

[2] The full scenario results are available at https://open.canada.ca/data/en/dataset/5a6abd9d-d343-41ef-a525-7a1efb686300.

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Financing Climate Change Mitigation Using Green Sukuk

BY DINA AZHGALIYEVA AND ZHANNA KAPSALYAMOVA

Abstract

Using global data from Bloomberg over the period 2017-2021, this paper provides a review of issuance and policies promoting Green sukuk, a Shari'ah-compliant financial instrument that is designed to fund environmentally friendly projects.

Introduction

Countries in Southeast Asia, such as Indonesia, Thailand, and Viet Nam, have announced their net-zero carbon emission targets by mid-century at the COP26 and financing climate change mitigation has been at the forefront of discussions for making ambitious climate action a reality (Azhgaliyeva 2021a). Limiting global warming to within 1.5°C will require rapid, far-reaching, and unprecedented changes in all sectors (Azhgaliyeva, Rahut and Morgan 2021). Such a transition requires substantial investments from both public and private funds (Azhgaliyeva and Mishra 2021).

Green sukuk, green Islamic financial instrument, have the potential to unlock investments in climate change mitigation and adaptation, particularly access to private and international finance from responsible investors with green investment targets. Studies on green bonds are abundant, however, the literature on green sukuk is narrow and usually focuses on a case study of one or two countries. Our study attempts to fill this void in the literature by providing a review of the green sukuk concept, policies, and discussion over the green sukuk issuance, using the global data on green sukuk from Bloomberg over the period 2017-2021.

The Concept of Green Sukuk

Green sukuk are Shari'ah-compliant financial instruments that are designed to fund environmentally friendly projects (Alam et al., 2016; Azhgaliyeva 2021b, c). Sukuk in Arabic refers to certificates that serve as proof of asset ownership, such as assets of specific projects or investment activities (Mat Rahim & Mohamad, 2018). Similar to sukuk, green sukuk adheres to Shari'ah principles of risk sharing, the prohibition of interest (riba), exposure to excessive risk (gharar), and speculative behavior (maysir) (Güçlü, 2019). Islamic finance supports real economic activities and sustainable development; bans products with gambling, short sales, and financing of activities which are destructive to society (Kammer et al., 2015).

Conceptually green sukuk is similar to a green bond, in that its proceeds are used to fund environmentally friendly projects. However, green sukuk represents "the property right of the underlying asset, while green bonds represent the right to claim" (Aassouli et al., 2018).

The literature on green sukuk is limited. The extant studies argue that green sukuk and sukuk, in general, are compliant with sustainability goals and have the potential to address environmental challenges, stimulate conservation of natural resources and environmental protection (Al-Roubaie & M. Sarea, 2019; Kassim & Abdullah, 2018; Moghul & Safar-Aly, 2015; Obaidullah, 2018). Growing energy demand, limited financing from commercial banks in the MENA region, and South-East Asia, a growing interest to invest in socially responsible investment can further stimulate the development of green sukuk market (Kassim and Abdullah, 2018). Literature studying green sukuk after the first issuance in 2017 focused mostly on country cases in Indonesia and Malaysia (Abubakar & Handayani, 2020; Keshminder et al., 2019; Rahim & Mohamad, 2018; Siswantoro, 2018). However, green sukuk issuance is growing in MENA. Over the period 2019-2020 green sukuk was issued in Saudi Arabia and UAE (Figure 3).

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Islamic finance is consistent with environmental, social, and governance objectives, United Nations principles for responsible investment, and the 17 United Nations Sustainable Development Goals (Deloitte & Touche, 2017). However, the terms "socially responsible investment" or "green" financing are novel to the Islamic finance literature (Moghul & Safar-Aly, 2015).

There are challenges to growing the green sukuk market. Such list of challenges includes lack of knowledge and skills; high transaction cost (Deloitte & Touche, 2017); lack of universal standards on green sukuk as most of the standards are set by organizations and may differ, voluntary nature of the process (Güçlü, 2019); lack of an assessment and green performance evaluation, verification system and independent verification agencies to certify the green initiatives (Kassim and Abdullah, 2018); high-risk profile of green sukuk projects due to construction and operation of green technologies (Kassim and Abdullah, 2018); the small size of the sukuk market leads to its low liquidity in the secondary market; low awareness of green investment and green sukuk (Aassouli et al., 2018; Güçlü, 2019; Kassim & Abdullah, 2018). That further complicates the diligence process for investors, due to the challenges associated with the ability to compare environmental impact between projects.

Policy support

Green sukuk market development receives government support, mainly in Malaysia and Indonesia (Table 1). In 2014 the Securities Commission Malaysia introduced a national Sustainable and Responsible Investment (SRI) Sukuk Framework. The Islamic Fund and Wealth Management Blueprint for Sustainable Investment provide strategies to invest in Islamic products

Table 1: Green Sukuk National Policies in Indonesia and Malaysia

Country	Policy Title	Policy Implementation Date	Policy Description
Indonesia	Green Bond and Green Sukuk Framework	2017	Eligible projects are renewable energy, energy efficiency, resilience to climate change or disaster risk reduction, sustainable transport, waste to energy and waste management, sustainable management of natural resources, green tourism, green buildings, and sustainable agriculture. Excluded projects are new fossil fuel-based electric power generation capacity, large-scale hydro plants, and nuclear and nuclear-related assets.
Indonesia	Sovereign Green Sukuk	2018-2021	Perusahaan Penerbit SBSN Indonesia has issued $7 billion (nearly 60% global green sukuk) of sovereign green sukuk.
Malaysia	Sustainable and Responsible Investment Sukuk Framework	August 2014	Eligible projects are natural resources, renewable energy and energy efficiency, and community and economic development.
	Green Sustainable and Responsible Investment Sukuk Grant Scheme	July 2017	Cost of external reviewer for issuing green bonds compliant with the SRI Sukuk Framework can be subsidized at 90% of the costs of independent review, but up to RM300,000.
Malaysia	Income tax exemption	January 2018	Income tax exemptions for recipients of the Green SRI Sukuk Grant Scheme.
Malaysia	Tax deduction	2017	Tax deductions on the issuance costs of SRI sukuk.

Source: Azhgaliyeva, Kapoor and Liu (2020); Azhgaliyeva 2021c; Bloomberg terminal.

that have sustainable features (Aassouli et al., 2018). Proceeds of SRI sukuk can be applied to fund the projects in natural resources, sustainable energy, economic development, and waqf properties/assets (Aassouli et al., 2018). Additional incentives are provided in Malaysia for sukuk that comply with the SRI Sukuk framework:

- *Green SRI Sukuk Grant Scheme* for the cost of external review for labeling sukuk green (90% of the cost, but not greater than MYR 300,000) (Azhgaliyeva et al., 2020);
- tax deduction on the issuance cost;
- income tax exemptions for recipients of the Green SRI Sukuk Grant.

After the implementation of these policies, corporates issued green sukuk in Malaysia, most of which are the first-time issuers.

Indonesia also has a national 'framework and regulation for green bond issuance' and a national 'Green Bond and Green Sukuk Framework'. Eligible green projects include "renewable energy, energy efficiency, resilience to climate change or disaster risk reduction, sustainable transport, waste to energy and waste management, sustainable management of natural resources, green tourism, green buildings, and sustainable agriculture" (Azhgaliyeva et al., 2020). Green sukuk in Indonesia, the largest green sukuk issuing country, is issued by a public organisation, Perusahaan Penerbit SBSN Indonesia. Public issuance of green sukuk can promote private issuance by providing liquidity and initial market products, as well as by educating investors about green sukuk.

In 2012 CBI, the Clean Energy Business Council of the Middle East and North Africa, and the Gulf Bond and Sukuk Association established Green Sukuk Working Group (Rahman et al., 2020). It develops guidance and practices related to the issuance of sukuk for sustainable projects (Kassim and Abdullah, 2018). Despite some MENA countries experience a boom in clean energy projects, green sukuk market development is behind Malaysia and Indonesia, due to the region's heavy reliance on the profits from the oil sector and therefore lower reliance on debt finance. However, changing oil prices and lowered perspective for rapid oil growth, will affect the demand and supply of other financial instruments, including green sukuk.

Similarly, Turkey only recently started to facilitate the understanding of Islamic finance in clean energy projects. Istanbul International Center for Private Sector and Development under the Global Islamic Finance and Impact Investing Platform (GIFIIP) hosted a meeting of stakeholders from the public and private sector to study the role of Islamic finance in clean energy projects in Turkey in March 2018 (Deloitte & Touche, 2018). The first sustainable Sukuk in Turkey is issued by a power company Zorlu Enerji in June 2020. Zorlu Enerji prepared the framework aligned with the Green Bond Principles and identified renewable energy, sustainable energy supply, sustainable infrastructure, and clean transportation as key eligible project areas.

Overall, the green sukuk market and green sukuk policies are less widely spread. Therefore, it is vital to carefully tailor policies required to unlock the potential of green sukuk.

Green sukuk issuance

The first green (labelled) sukuk was issued in 2017 in Malaysia by the solar energy producer, Tadau Energy. By 2019, the annual issuance of green sukuk increased five times. The accumulated issuance of green sukuk reached $12 billion by 2021. Nevertheless, green sukuk was only 0.65% of sukuk and 0.30% of green bond issuance in 2021 (Figures 1-2).

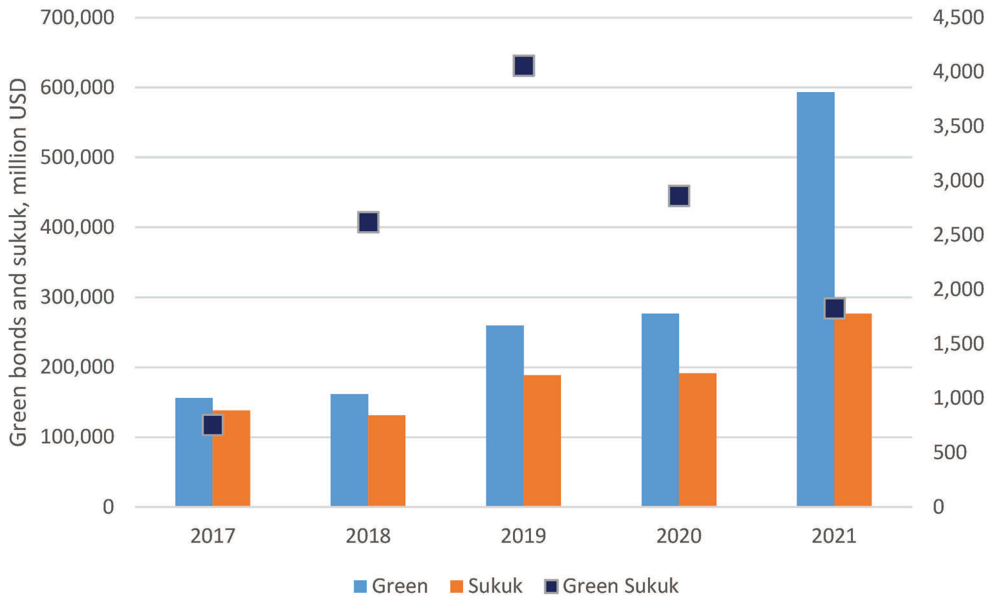

Figure 1: Issuance of green bonds, sukuk and green sukuk by years
Data source: Bloomberg terminal

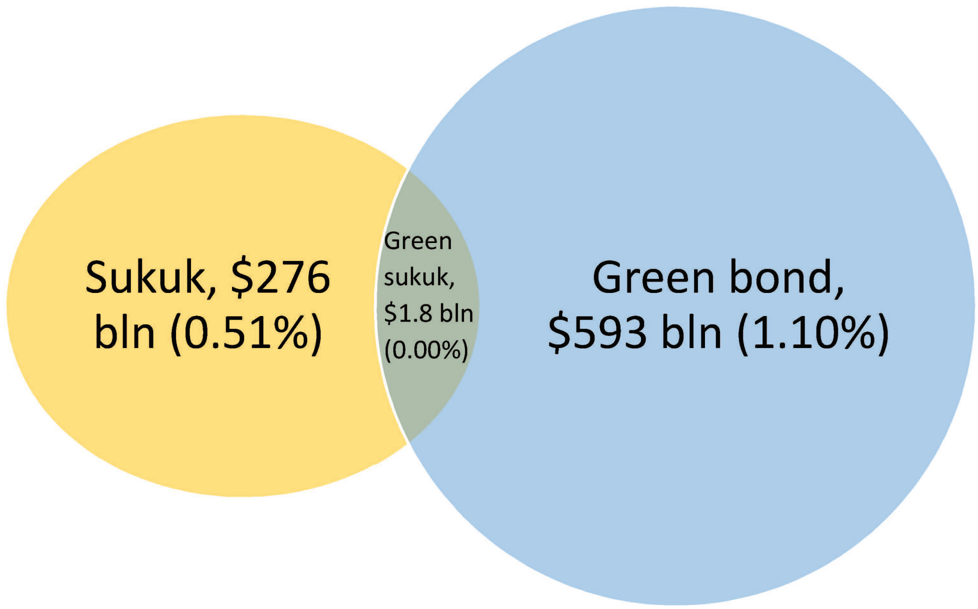

Figure 2: Global issuance of sukuk, green bonds and green sukuk in 2021, share in total bond issuance
Data source: Bloomberg terminal

According to Bloomberg data over the period 2017-2021, (labelled) green sukuk securities were issued by 15 issuers from four countries, Malaysia, Indonesia, UAE, and Saudi Arabia, as well as by the Islamic Development Bank (Figures 3). These four countries are all top issuers of sukuk (Figures 4). Green sukuk issuing sectors are government, energy, real estate and banks. A detailed list of green sukuk issuance is provided in Appendix A.

Demand for Green Sukuk

Demand for green sukuk is represented mainly by investment advisors, banks, insurance companies, and sovereign wealth funds (in descending order). Interestingly, country investors in green sukuk are nearly all top country investors in sukuk (Figure 5), which means that countries with high demand for sukuk represent a demand for green sukuk. Also, most investors in green sukuk are the top investors in sukuk. Thus, green sukuk attracts investors in sukuk with environmental objectives.

Most issuers of green sukuk rely on international demand, except for issuers from Malaysia. Unlike issuers from other countries, issuers from Malaysia issue green sukuk in domestic currency. United States dollar-denominated issuances make up 78% of green sukuk issuances, followed by ringgit-denominated (12%), euro-denominated (9%) issuances (Figure 6). Green sukuk that are denominated in United States dollars and euro attracted international investors, while Malaysian ringgit-denominated green sukuk issued in Malaysia attracted local investors only.

Conclusions and policy implications

This paper provides a review of Green sukuk, a Shari'ah-compliant financial instrument that is designed to fund environmentally friendly projects. Although the share of green sukuk in green bonds is very small (0.3%) the annual issuance was growing fast in 2017-2019 (before COVID-19 pandemic) in top sukuk-issuing countries, particularly in South-East Asia (i.e. Indonesia and Malaysia). From 2017 to 2019, the annual issuance of green sukuk increased five times. By 2021, total green sukuk issuance reached $12 billion.

Green sukuk issuance in South-East Asia, i.e. Indonesia and Malaysia, is driven by policy support. Although, Malaysia is not the largest green sukuk issuer, it has the largest number of issuers. Malaysia promotes private green Sukuk issuance by subsidising the cost of external review for labelling sukuk green and providing tax incentives for green sukuk issuance. After the implementation of the SRI sukuk grant and tax incentives entities have issued green sukuk, most of which are

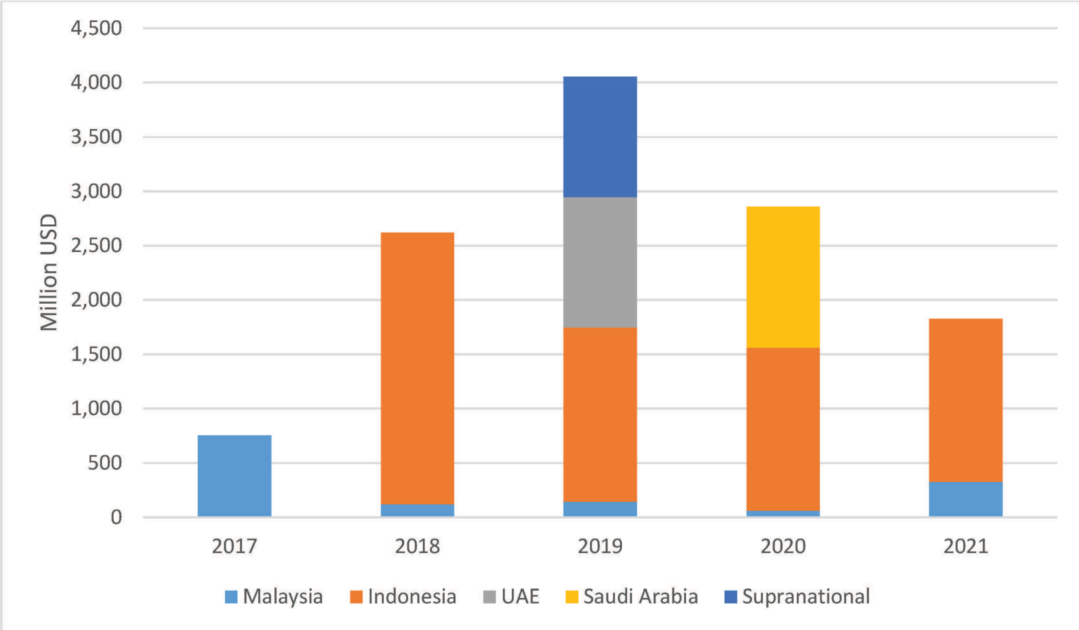

Figure 3: Issuance of green sukuk by countries and years
Data source: Bloomberg terminal

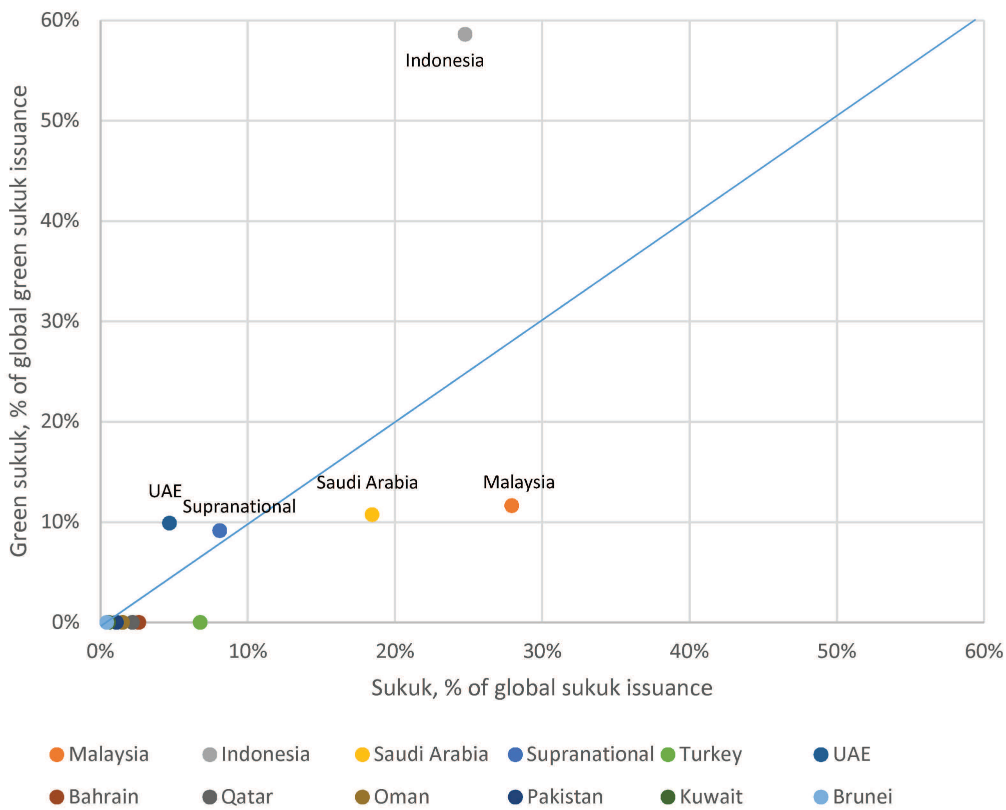

Figure 4: Listing of sukuk and green sukuk as a share of global listing (2017-2021)
Note: Countries included are those which listed more than 0.4% of global sukuk over the period 2017-2021.
Data source: Bloomberg terminal

first-time issuers. Policies, reducing the cost of labeling sukuk green, are especially beneficial for the first-time issuers.

In Indonesia, the largest green sukuk-issuing country, green sukuk is issued by the government. Public issuance may promote private issuance by providing

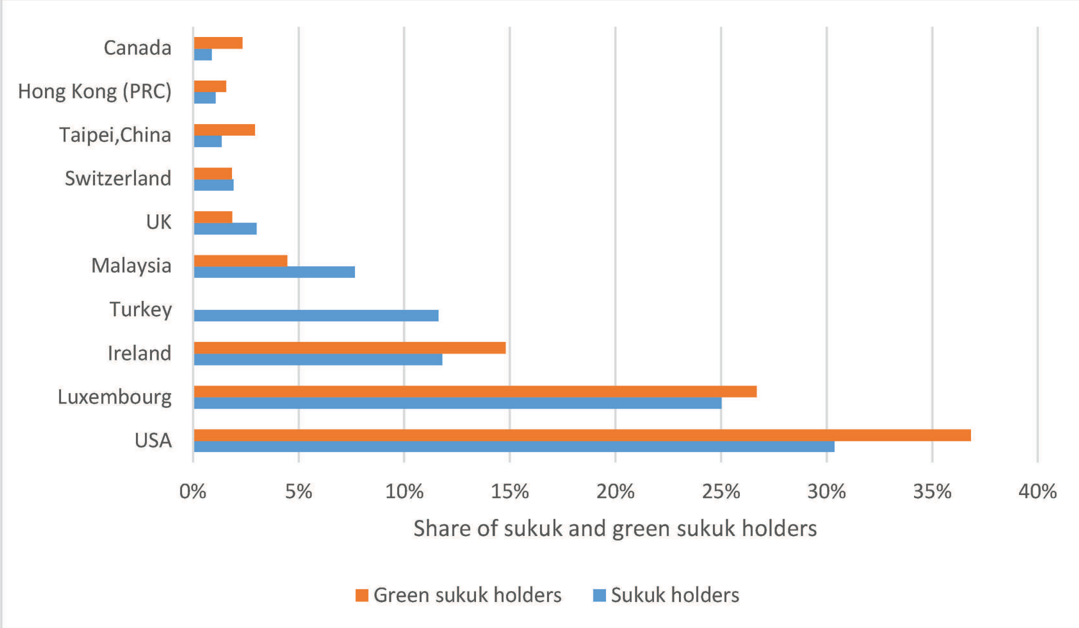

Figure 5: Demand for sukuk and green sukuk (2017-2021)
Data source: Bloomberg terminal

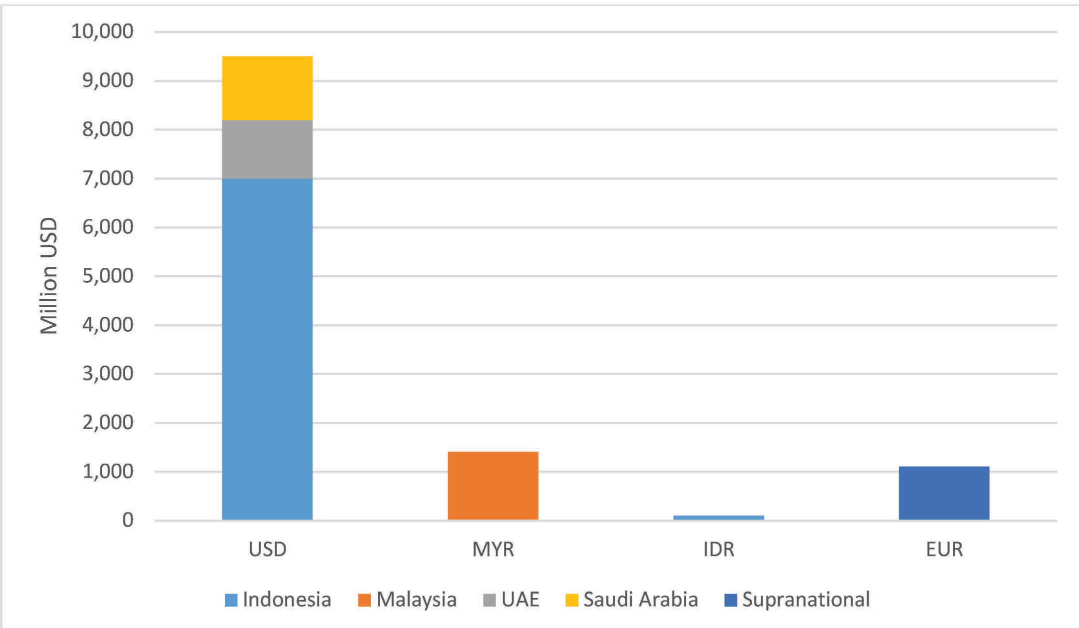

Figure 6: Issuance of green sukuk by currency (2017-2021)
Note: MYR – Malaysian ringgit, IDR – Indonesian rupiah
Data source: Bloomberg terminal

liquidity, engaging, and educating investors about green sukuk.

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Appendix A

Table A1. Green sukuk issuance

Issuer	Date of issuance	$ mln	Issuer industry	Country of risk	Project	Project location	Currency	ICMA GBP	ACMF ASEAN GBS	SRI	External review/ second opinion	Green shading rating
Tadau Energy	Jul-17	58	Energy	Malaysia	50 MW Solar	Malaysia	MYR	√		√	CICERO	Dark green
Quantrum Solar Park	Oct-17	236			50 MW Solar			√		√	CICERO	Dark green
PNB Merdeka Ventures	Dec-17	461	Real estate		Green building			√	√	√	CICERO	Medium green
	Dec-19	29						√	√	√		
	Jun-21	103.44										
Sinar Kamiri	Jan-18	63	Energy		49 MW Solar			√		√	RAM Consultancy	Tier-1 Environmental Benefit
UiTM Solar Power	May-18	56			Solar			√	√	√	CICERO	Dark green
	Mar-21	1.75										
Telekosang Hydro One	Jul-19	115			40 MW Hydro			√	√	√	RAM	
Cypark Ref	Oct-19	5			Solar			√				
Perusahaan Penerbit SBSN Indonesia	Mar-18	2,500	Government	Indonesia	Green projects	Indonesia	USD	√			CICERO	Medium green
	Feb-19	1,500			Green projects			√				
	Jun-20	1,500			Green projects			√				
	Jun-21	1,500										
MAF sukuk	May-19	600	Real estate	UAE	Green projects (Renewable energy, energy efficiency, water, green buildings)	Middle East and North Africa	USD	√			Sustainalytics	
	Oct-19	600						√				
Islamic Development Bank (IDB) Trust Services	Dec-19	1,136	Bank	Supranational	Social and green projects		EU	√			CICERO	Medium green
Saudi Electricity	Sep-20	1,300	Energy	Saudi Arabia	10 mln. smart meters & connection to 3587 MW of renewable energy	Saudi Arabia	USD	√			Vigeo Eiris	
Leader Energy	Jul-20	61	Solar power	Malaysia	solar PV 49MW	Malaysia	MYR		√			
Pengurusan Air Selangor	Oct-21	104	Public water supply	Malaysia	Renewable energy, sustainable water management, green building, exc. fossil fuels, alcohol, gambling, tobacco and weaponry	Malaysia	MYR	√	√	√	RAM sustainability	Tier-1, 2, 3 (depending on project) Environmental Benefit
reNIKOLA Solar	May-21	95	Energy	Malaysia	refinance 3 large-scale solar power plants 88 MWp	Malaysia	MYR	√	√	√	RAM sustainability	Tier-1 Environmental Benefit

Source: Own elaboration using data from Bloomberg, Climate Bond Initiative, World Bank (2020) and other.

Launch of the Uganda Association for Energy Economics

BY DR. LIVINGSTONE SENYONGA

April 28, 2022

The Uganda Association for Energy Economics (UAEE)

Preamble:

The Uganda Association for Energy Economics (UAEE) was launched on 28th April 2022 at Makerere University Business School (MUBS), Uganda. Since 2008, MUBS has been engaged in developing the capacity to offer quality education and research in energy economics. Using Norwegian Higher Education (NORHED) projects support, which is funded by the Norwegian Agency for Development Cooperation (NORAD), MUBS developed collaborations with Norwegian Universities including the Norwegian University of Life Sciences (NMBU) and the Norwegian University of Science and Technology (NTNU). MUBS collaboration with Norwegian Universities and the selfless efforts of Professor Olvar Bergland (former president of the Norwegian Association for Energy Economics-NAEE) led to the establishment of specialized energy economics academic programs, including a bachelor's, masters, and Ph.D. program in energy economics and governance. These are the first of the kind in Uganda and the entire East African region, which is currently undergoing an energy-led economic growth revolution.

To strengthen energy economics education and research, a team of MUBS faculty led by Dr. Livingstone Senyonga, Prof. Muhammed Ngoma, and Mr. Bosco Amerit guided by Prof. Olvar Bergland, and the MUBS management under the leadership of Prof. Waswa Balunywa, founded the Uganda Association for Energy Economics (UAEE). UAEE provides a platform for people and institutions with an active interest in energy economics to network and share knowledge, experiences, practices, and opportunities. The association has a membership including academic faculty, independent researchers, students, and technocrats from government institutions. Its doors are now open to more new members.

The UAEE was registered under the laws of Uganda and the IAEE council formally recognized UAEE as an affiliate on the 27th April, 2022. Because of UAEE's affiliation with IAEE, faculty members of the University of Dar-es-salaam have expressed interest to join UAEE as they plan to start their own Tanzania Association for Energy Economics. A program to popularize IAEE activities across East Africa and subsequently have a pan-African energy economics movement is in the works, starting with a joint student's energy modeling training camp between Uganda and Tanzania, which will take place in August 2022.

a) The launch of UAEE

The UAEE was officiated by the Vice President of IAEE in charge of affiliations, Prof. Roula Inglesi-Lotz, with a well-attended public lecture titled "Emerging Issues from the Current Geopolitics and their Impact on Africa's Energy Sector". The discussant for the public lecture was Prof. Olvar Bergland. The following day Prof. Inglesi-Lotz gave a second lecture to MUBS faculty and graduate students of energy economics and governance on the topic of sustainable energy transitions.

b) The purpose for forming and launch of UAEE

The lunch was in fulfillment of one of three NORHED II objectives that support the establishment:

- *To develop a professional network along the lines of an International Association for Energy Economics of East Africa, as a mechanism for fostering communication among energy sector analysts and supporting informed discussions on issues related to energy economics and policy.*
- *To use the international network of energy economists to mobilize annual energy economics research conferences and modeling boot camps and workshops.*
- *To support the dissemination of peer-reviewed publications and policy briefs among stakeholders in Uganda and Tanzania.*

UAEE shall provide a platform for people and institutions with an active interest in energy economics to network and share knowledge, experiences, practices, and opportunities. This association is a precursor to the launch of the East African regional association for energy economics.

c) Launch Activities

Public Lecture

A public Lecture on emerging global energy issues associated with the current geopolitics, conflicts, and their possible impact on the energy sector in Africa by Prof. Roula Inglesi-Lotz. The attendance was more than expected.

Students' panel discussion

A panel of six Ph.D. students discussed experiences on their Ph.D. journey and shared captivating experiences during their various engagements at the IAEE Doctoral Seminar 8-9 June 2018, Groningen, The Netherlands, and at the Advanced Energy Modeling between July 8-19, 2019 in Beijing, China at the School of Economics and Management, China University of Geosciences, Beijing (SEM-CUGB). The discussion further touched on the issue of gender with female students narrating their experiences of what is involved in being a graduate student, a wife, and a mother.

UAEE Launched

The Interim President of the UAEE, Dr Livingstone Senyonga presented a brief to the symposium and introduced the interim committee. That the UAEE was a fully registered organization under the laws of Uganda and had been admitted as an affiliate to the worldwide energy economics association, the International Association for Energy Economics (IAEE) on April 27, 2022, as the 29th affiliate.

Vision of UAEE

A hub for networking and information sharing on energy economics.

Mission

To enhance knowledge in energy economics through the provision of evidence-based inclusive policies and best practices toward sustainable use of energy sources.

Objectives

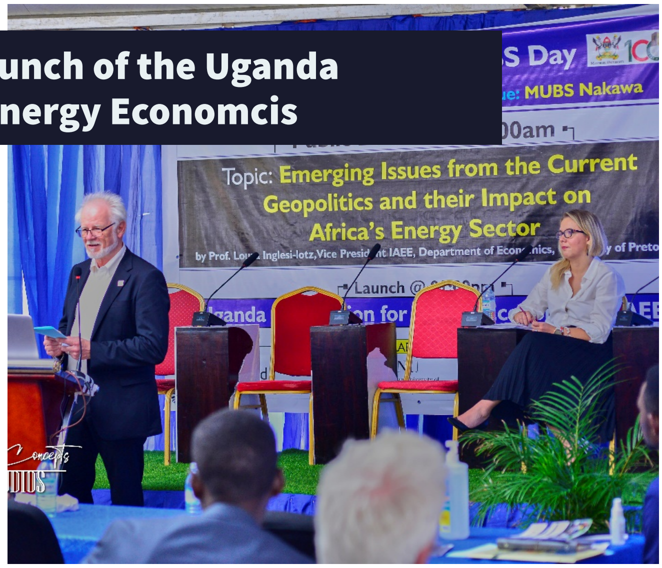
At its launch, the objectives of UAEE included:

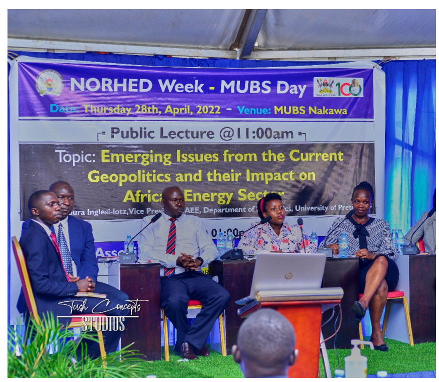
a) Provide for the mutual association of persons interested in energy economics in order to create a forum for professional discussion, through conferences, seminars, and webinars.
b) Provide a means of professional communication and exchange of experience and ideas among persons interested in energy economics.
c) Promote professional communication among persons interested in energy economics from different countries, especially in Africa where a revolution of energy-led economic growth is taking place.
d) Educate the community on energy economics issues by developing and sharing expertise in energy economics that may be useful in adopting public policies and understanding public issues related to energy resources and doing so in an apolitical manner.
e) Promote higher education, research, and publication in energy economics and bridge the gap between researchers or scholars, and practitioners of energy economics who are the primary users of energy economics research outputs.
f) Enter into any arrangement or collaborations with Organizations, entities, governments, or authorities that may seem necessary to enhance the attainment of the main objective of UAEE, which is popularizing energy economics education and research to support the formulation and implementation of evidence-based energy resource policies.

Future plans

1. UAEE is organizing an east Africa-wide energy modeling boot camp to be held in Arusha Tanzania from 10th -19th August 2022.
2. Planning to hold a joint meeting between Nigeria and South Africa Associations for Energy Economics to begin discussing the possibilities of holding joint activities including a pan-African conference.

Scenes from the Launch of the Uganda Association for Energy Economcis





Climate Change Presents the Greatest Opportunity to Leverage Technology to Eliminate Energy Poverty

BY GAUTAM SWAMI

Will finance and technology rise jointly to the emerging challenges and opportunities?

The giant leaps in society's standard of living, life expectancy, education, literacy, and global trade would not have been possible without the expertise and scale of our modern energy industry. Yet, the global energy industry will change more in the next fifty years, than in the past hundred and fifty years.

Environmental degradation, long-term changes in natural systems, and the increasing confidence among the global scientific community with regards to the attribution of increases in greenhouse gas emissions to the sustained use of fossil fuels over the past century, have compelled a serious discussion about the future of the energy industry.

Transportation, heating & cooling, metal refining, agriculture, industrial processes, and electricity generation are all facing significant headwinds and undergoing seismic changes simultaneously, as numerous countries prepare to achieve net-zero emissions between 2050 and 2070.

Scenarios and pathways created by global bodies like the Intergovernmental Panel on Climate Change (IPCC), the UK's Climate Change Committee (CCC), the US' Department of Energy (DOE), the International Energy Agency (IEA), and many others point to a clear acknowledgement that the energy industry needs to act with alacrity to stem further emissions attributable to its activities.

While the initial reaction could be that of denial, the sheer amount of financial capital at risk of being written off as stranded assets ought to be enough to make participants and financiers assess the consequences of not changing course. If governments, financial lenders, and operators conduct detailed stress tests across their portfolios, it would be hard to make a case for the status quo.

For technologists, a breakdown can often be the best time for a breakthrough. The amount of funding going into "climate-tech" ventures is an indication of the optimism and risk-taking prevalent in the Research & Development (R&D) and venture capital (VC) industries. Investments are flowing into Electric Vehicles (EVs), Artificial Intelligence (AI), Carbon management, material science, food technology, and renewable energy in record amounts. Both mitigation and adaption technologies are raising large sums of money. This rapid increase in momentum will drive down marginal costs, encourage widespread adoption, and increase affordability of modern technologies, processes, and devices.

Even more encouraging is the interest being shown by the Venture arms of traditional energy companies as they churn their upstream portfolios to reduce their absolute emissions and carbon intensities. Their interest also extends to innovations in their transportation, refining, chemicals, and petrochemicals divisions. This market will see an increase in Carbon Capture, Utilization, and Storage (CCUS) investments over the coming decade. Global Oil & Gas companies are also declaring net-zero targets themselves and are expanding their wind- and solar-power portfolios to achieve these targets.

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All opinions expressed are his own.

The world's incumbent energy and utility companies ought to seize the opportunity to replicate their success in delivering affordable and accessible energy, while generating shareholder returns and achieving net-zero targets.

Energy companies' expertise in commodities trading, logistics, and offshore projects is enabling deep value-stacking too. For example, using electric equipment in drilling, production, heating, boiling, compressing, and pumping will lower oil companies' absolute emissions and operating expenses. Using surplus lease areas to develop solar energy projects will open another avenue of monetization. In offshore oil production operations, companies can lower their carbon footprint by powering production platforms from electricity generated by floating wind projects, instead of diesel or gas.

Over in the utilities business, the US is now racing towards generating a hundred percent of America's electricity from fossil-free sources by 2035. This target will only accelerate investments in wind and solar energy, away from coal and natural gas. The EU, China, Japan, South Korea, and India are also expanding their procurement of clean power using long-term power purchase agreements (PPAs). The UK's Crown Estate recently awarded 25 GW of offshore wind capacity in leases. To put that in context, the UK's current offshore wind capacity is 10 GW. India's solar tariffs are at all-time lows and barring inflationary pressures, the trend will continue downwards. Green hydrogen could leverage the success of offshore wind projects and emerge as a bigger than expected contributor to industrial decarbonization. The planned increase in the use of Microgrids could lead to potential revenue losses for integrated utilities, while increasing resiliency and independence of vulnerable communities. Automobile companies are committing ever-increasing amount of capital to designing and manufacturing electric vehicles (EVs), along with the associated charging infrastructure.

If we look at finance for energy projects, ESG funds have amassed large assets under management (AUM) and are taking an increasingly activist role in forcing

Boards and Management of investee companies to commit to decarbonization. These funds are joined by pension funds, university endowments, and sovereign wealth funds in aligning investors' values with the funds' asset allocations. Banks' portfolios could churn to reflect increasing investments in renewable energy in comparison to production, transportation, processing, and storage of fossil fuels. Corporate asset allocation and public budget planning processes could also change to promote technological solutions for adapting to ecological transformation.

Interestingly, the risk management and actuarial industries are facing an epistemological break in their models and are gradually reconciling the impact of climate risks on their portfolios. Some companies may seek to completely avoid those physical risks that are deeply intertwined with climate change. The impact of localized events like wildfires, storms, floods, etc. on tax revenues will force governments at all levels to act as a backstop for impacted citizens and communities. The Taskforce on Climate-Related Financial Disclosures (TCFD), Network of Central Banks and Supervisors for Greening the Financial System (NGFS), Science-based Targets Initiative (SBTI), and other supra-national bodies are already looking into potential impacts of revenue losses and potential contingent liabilities.

Another potential avenue of global regulation could be carbon-pricing and carbon-taxation. Grants, tax credits, tax offsets, and other fiscal instruments could become increasingly important to financing affordable real estate via sustainable finance programs, municipal bonds programs, and corporate investments. Second-order effects to changes in fiscal and financial behavior could increase unfunded liabilities, as well.

As an increasing number of economists model how climate risks translate into financial risks and eventually impact financial stability, the need to utilize carbon emissions data easily will increase. Societal demands for equity and environmental justice will also play an important role in policy-making and fiscal budgeting. Eradicating energy poverty, providing fair access, remediation of environmental losses, and avoiding climate-driven hazards could become key considerations of infrastructure financing.

In conclusion, governments, energy companies, investors, and end-users will have to work together to lower the carbon footprint of their operations while ensuring reliability and affordability. Investors will also need to brave commodity price volatility, temporary phases of supply chain disruptions, and inflation on the way to greener portfolios.

A Post-COP26 Review of the Global Efforts and Opportunities to Combat Climate Change

BY JOHN HOLDING

Abstract

This paper will firstly review the history of the global efforts to counteract climate change under the auspices of the UN and how these efforts have evolved and shifted over time. Looking forwards a reality check regarding fossil fuel use plus the opportunity for carbon dioxide removal techniques will be explored.

John Holding is a retired Strategic and Business Planning Manager formerly with Chevron in the international upstream oil and gas sector. His interests now encompass the analysis of wider global energy issues. He has facilitated student events at USAEE annual conferences for ten years where he is now a Senior Fellow. He resides in the south-east of the United Kingdom and can be reached at holding273@btinternet.com

A critique of global efforts to date to combat climate change

COP26 which concluded in Glasgow Scotland in mid-November 2021 presents a timely opportunity to review the status of the global efforts to counteract climate change. The current year 2022 represents thirty years from the founding of the UNFCCC in Rio de Janeiro - the "Earth Summit" – held in June 1992 [1]. Moreover 2022 represents the point at which some thirty years hence the *global goal of substantially reducing global emissions by 2050* should have been realized [2].

COP26 closed by stating *The aim of the UK COP26 Presidency was to keep alive the hope of limiting the rise in global temperature to 1.5°C, and the Glasgow Climate Pact does just that* [3]. This wording could similarly have been applied to a parallel global challenge; the spectre of COVID-19 patients being 'kept alive' on ventilators in intensive care hospitals comes to mind. Sadly though, very many such patients have not survived. So, the broader question is, has COP26 made real progress towards the ultimate aim of the creators of the Framework Convention on Climate Change - that is, *preventing "dangerous" human interference with the climate system"* [4]? The notion of 197 Parties to the Convention [5] striving to achieve Net Zero emissions by a date some thirty years from now might be considered idealistic, given the politico-economic challenges of (i) the absolute costs associated with energy transitions, (ii) the need for wholesale revamping of road transportation, power transmission infrastructures along with upgrading heating and cooling systems in existing buildings, and (iii) the developing world's industrialization, urbanization and poverty alleviation programs. The Arab News published on November 11, 2021 as COP26 was ending [6] elaborated some of the fundamental developing world issues and promoted the application of the *Circular Carbon Economy* approach [essentially, energy from waste; see for example [7]]. Furthermore, unexpected events can intervene such as the first NDC submissions made pursuant to the Paris Agreement [8] which were confronted by the exigencies from the ongoing COVID-19 pandemic. At the time when the NDC submissions would have been under preparation, it was most unfortunate timing that events forced the WHO to make the global pandemic declaration in March 2020.

With the origins back in 1972, it was the Stockholm Conference on the Human Environment [9] [10] that merged for the first time the subjects of the world's environment with sustainable development. It therefore placed environmental issues at the forefront of international concerns and marked the start of a dialogue between industrialized and developing countries on the link between economic growth, the pollution of the air, water, and oceans and the well-being of people around the world. The COPs of the twenty-first century continue to wrestle with these disparate subjects.

The establishment of the UNFCCC in Rio in 1992 included the commitment [Article 4, 2. (b)] that Annex I Parties revert, individually or jointly, to their 1990 emissions levels of carbon dioxide and other greenhouse gases (GHGs) [11]. The first Conference of the Parties, COP1, was convened in Berlin in 1995 setting the path towards legally binding obligations on such emissions levels which were then cemented by the 1997 Kyoto Protocol (COP3). 192 parties ratified the Protocol whilst 37 industrialized nations plus the European Union (that is, the majority of Annex I parties) agreed to cut their country's emissions to 5% below 1990 levels between 2008 and 2012. However, the USA dropped out in 2001 whilst "owing to a complex ratification process" the Protocol itself did not enter into force until February 2005 [12]. Then Canada denounced it in 2012 on the basis that without the participation of the USA and China, the two largest emitters of GHGs, the Protocol was unworkable and therefore a new pact was needed [13].

In 2009 efforts shifted away from the Kyoto Protocol approach at COP15 in Denmark; when the Copenhagen Accord committed to the long-term goal of limiting the maximum global average temperature increase to no more than 2°Celsius above pre-industrial levels, subject to a review in 2015. However, this was not binding nor was there an agreement on how to do this in practice. Furthermore, the conference also acknowledged a key demand by vulnerable developing countries to consider limiting the temperature increase to not more than 1.5°C. Other major outcomes from COP15 were that developed countries promised to fund actions to reduce GHGs and to provide for adaptation in developing countries by providing US$30 billion during 2010-

2012 plus to mobilize long-term finance of a further US$100 billion a year by 2020 [14].

Oddly in retrospect, the Kyoto Protocol was adopted for a second commitment period, starting in 2013 and lasting until 2020, by means of the Doha Amendment (COP 18) in 2012 [15]. Parties to this Amendment committed to reduce their GHG emissions by at least 18 percent below 1990 levels in this period.

A more objective approach evolved in 2015 when the Paris Agreement was signed at COP21. This effectively supplanted the Kyoto Protocol and now forms the basis for current conversations on climate change. The drive was *to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°Celsius* [16]. The Agreement included for enhanced support to assist developing and the most vulnerable countries to participate in line with their own national objectives. Perhaps the most notable outcome from Paris was that all Parties were required to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. There was also to be a global stocktake every 5 years to assess the collective progress. Significantly 193 Parties out of 197 Parties to the Convention became Parties to the Paris Agreement. Overall, this COP appears to represent a near global commitment to addressing climate change with the submission of national targets which would be subject to peer review.

Meanwhile, the IPCC's Special Report (SR15) on *Global Warming of 1.5°C* [17] was being developed leading to publication in October 2018 just ahead of COP24 which was held in Katowice Poland – a country where 80% of the electricity is generated from coal. Delegates at Katowice clashed over how to respond to the IPPC's Special Report which linked the potential to limit global warming to 1.5°C with a 2050 net zero target for GHG emissions. Whilst some participants wished to clearly signal the need to stay within this temperature limit, the COP *in toto* produced a disappointing outcome despite UN secretary-general António Guterres' personal intervention at the conference [18].

The pronouncements and declarations made at COP26 in Glasgow in November 2021 are still fresh in our minds – particularly the carefully worded statement about keeping alive hopes of limiting the rise in global temperature to 1.5°C [3]. Some key countries did not align to a 2050 target for net zero emissions; China, Russia and Saudi Arabia pledged a 2060 target whilst India declared 2070. Moreover, the last-minute action of India supported by China exasperated Conference President Alok Sharma as the closing statement was forced to be modified to *phase down* rather than *phase out* unabated coal power.

The overall result was summarized by The Economist, *Although 197 parties agreed a pact, the summit's closing moments were hardly jubilant.* [. . .] *Not the stuff of triumph; but not a trainwreck, either* [19]. Separately, The Times of India reported, *India on Sunday called the COP26 summit a "success". saying it put across the concerns and ideas of the developing world quite "succinctly and unequivocally" in front of the world community*. [. . .] [The deal] *recognises India's intervention for the world to "phase down. rather than "phase out" fossil fuels.* [20].

One thing clear is that the results of COP26, and this is generally applicable to all previous conferences, is that they do not garner unequivocal support for actions but produce a range of statements and carefully worded interventions that national delegations can 'live with', can 'sell' to their constituencies back home. Nevertheless, the mobilization annually of nearly 200 nations towards finding any sort of common action to deal with something as esoteric as climate change is remarkable. This, despite the changing objectives such as the merging of environmental issues with sustainable and economic development, the cutting of emissions by industrialized nations to below their 1900 levels, shifting the vocabulary between "global warming" and "climate change", limiting the global temperature rise to at least 2°C below pre-industrial levels, developing and openly submitting NDCs, targeting Net Zero emissions and agreeing massive transfer of money from richer to poorer countries. All this is impressive, and COP26 possibly more so, as it was held against the background of the surging COVID19 Omicron variant and the fact that a COP in 2020 had not taken place because of the pandemic. Glasgow was not a failure – at the very least, it actually took place, and "kept alive the hope . . ."

And, in a response analogous to the challenge of the Coronavirus and its mutations, the climate change response has shifted in the light of new information and predictive modelling. Novel insights and untested solutions have been offered, for example, carbon dioxide removal techniques – of which more will be said later.

Fossil Fuels - still with us in 2050?

COP26 saw NGOs, activists, civil society coalitions and renewable energy campaigners [21] press to keep fossil fuels in the ground [22], bemoaned the lost opportunity to "consign coal to history" [23] and criticized the new Carbon Offsetting agreement [24]. This latter which concluded Article 6 of the Paris Agreement [25], was critiqued by the Financial Times [26] noting that the inclusion in the system of inferior credits generated under the Kyoto Protocol [25 years ago] was a concern to some observers. However, Shell's Chief Climate Change Advisor opined that the completion of Article 6 *makes COP26 a success* [27]. On the other hand, Glasgow's achievement of removing public subsidies for fossil fuel extraction and unabated utilization hardly resonated with the NGO lobbyists. But, whatever the point of view, the practical application of energy finance and economics can operationalize the climate change actions that are necessary.

The general public may equate fossil fuels directly with CO_2 emissions, hence global warming and climate change; thus, crude oil and natural gas have had a rough time these last years whilst coal extraction and its unabated use is currently under very serious pressure. Still, a recent article in IAEE Energy Forum [28] by Dr. Salameh shattered some of the myths about the Global Energy Transition; "It is not possible [. . .] to simply ditch fossil fuels for renewable energy [. . .] Fossil fuels are simply more energy dense than other energy sources [. . .]" And with a emblematic reference to the world's travails over the last two years, "If anything, the pandemic has proven irrevocably the inseparable link between the global economy and oil."

International oil companies tend to express themselves more opaquely, proclaiming their altruistic credentials and concern for people and society in general. ExxonMobil declare "Energy and human development are inextricably linked", "Oil and natural gas play an important role over the coming decades in lower 2°C pathways" [29]. Shell's Energy Transformation Scenarios offer the view that "A better life for all requires sufficient energy to provide everyone with a decent quality of life", "Taking steps towards the goal of the Paris Agreement could be rewarding both economically and environmentally, although the necessary actions involve costs" [30].

Even the single greatest contributor to global carbon emissions of any company in the world since 1965 [31], Aramco, says "We believe in the power of energy to transform lives, enhance communities, advance human progress, and sustain our planet" [32]. China Energy, the largest power company in the world [33], proclaims "Clean Energy, Green Future" which will be realized by "determined efforts to achieve a low-carbon transformation featuring clean utilization of fossil fuels" [34].

It is possible that fossil fuels could move progressively into a transitional phase where, for example, power generation using abated natural gas CCGT generators will serve for peak shaving and stand-in support for intermittent renewable supplies. Abatement technologies might advance to allow continued use of fossil fuels in industrial production processes. The possibility of on-board abatement for the internal combustion engine has yet to materialize but research into capturing CO_2 from tailpipe emissions has indicated potential but "it may require several years to realize such system in practice" [35]. Electric Vehicles must be the answer of course, yet without government incentives and higher battery capacities so as "to say goodbye to EV range anxiety" [36] the public remains sceptical. The implication overall is that abated fossil fuels could become recognized as a *sustainable* energy source. McKinsey's *The Global Energy Perspective 2021* "more than half of all global energy demand comes from fossil fuels by 2050" [37]. This, if realized, would represent a decline from the 2020 figure of 83% reported in BP's Statistical Review [38] but may not be enough for a Net Zero or "less than 1.5°C" world.

The elephant in the room

When COP55 convenes in 2050 the delegates may or may not have cause to celebrate the achievement of Net Zero GHG emissions and a global temperature rise that has been kept markedly below 2°Celsius. Yet there may still be *an elephant in the room*; the accumulated volume of greenhouse gases residing in the atmosphere since industrialisation commenced, and which have been added to ever since . . . plus the prospect of emissions to come by virtue of population growth, food and land demands, poverty alleviation and technological progress demanded by the developing world.

CDR (Carbon Dioxide Removal), alternatively CCUS (Carbon Capture Utilization and Storage) or GGR (Greenhouse Gas Removal) are innovations that have been recognized in several quarters as potential climate change solutions – for example, the *IPPC Special Report on Global Warming of 1.5°C* [17] makes six references to CDR and states that it will almost certainly be required to achieve the 1.5°C limit on global warming. In their *Communication of long-term strategies* submitted to UNFCCC under the Paris Agreement [39], several countries such as Germany, the UK, the USA (whose document includes a useful discussion of CDR methods) state their intended use of CDR in achieving national net zero targets by 2050. A 2012 piece of research by Kriegler into the application of CDR concluded that it can be a game changer for climate policy [40] whilst a more recent paper (June 2020), also from Germany, looked into why virtually no action had been taken on this topic so far and emphasized the importance of CDR. This latter work was strongly endorsed (July 2020) by Shell's Chief Climate Change Advisor [41]. Moreover, the UK's Royal Society has declared (June 2021), "Carbon capture and storage (CCS) is essential for net zero emissions to be achieved in any economy using fossil fuels or releasing carbon in any other ways" [42].

Given this growing interest in CDR the USAEE launched, ahead of COP26, a virtual Student Case Competition seeking to respond to a request from a fictitious company (CRSV) to analyze global CDR opportunities for future investment needs and potential. Five student teams entered with the winners being a team from Carnegie Mellon University, Pittsburgh PA [43]. The team reviewed the main CDR contenders for the opportunities of likely interest to their client; Bioenergy with Carbon Capture and Sequestration, Direct Air Capture with Carbon Sequestration, Afforestation and Reforestation, Enhanced Weathering, Ocean Fertilization, Biochar and Soil Carbon Sequestration.

The conclusion here is surely that CDR offers not only a means of removing historic accumulations of CO_2 from the atmosphere but it can be applied concurrently as a mitigating element alongside global efforts to reduce GHG emissions.

A final word with respect to COP26; yes, more could have been achieved but at least the UK hosts tried hard. The conference was well-intended and demonstrated a positive engagement by delegates. The continuous pursuit of action on the environment by the developed and the developing world coming together at COPs must continue in order to pursue the aspirations laid out at the 1992 Earth Summit. These efforts should be maintained despite individual nations' challenges and limitations.

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Is Perceived Climate Friendliness Driving EV Adoption? Exploring Consumer Knowledge at Different Stages of the Vehicle Purchasing Process

BY STEFAN GAHRENS, BEATRICE PETROVICH, ROLF WÜSTENHAGEN, AND ALLESSANDRA MOTZ

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Abstract

Electric vehicles can significantly contribute to decarbonizing transport – but does that really matter to consumers? Based on a survey in Switzerland, one of the fast-growing European EV markets, we find that moving closer to the purchase decision the share of well-informed adopters increases, but their climate optimism decreases.

Keywords: Electrical Vehicles in Switzerland, Perceptions of Climate Friendliness, Emission Break-Even Mileage, Lifecycle Analysis, Health Action Process Approach (HAPA)

Part 1: Case Study on Electrical Vehicle Adoption in Switzerland

Decarbonization of transport is central for fulfilling climate goals:

Electrifying individual transport with electric vehicles (EV) and renewable energy (RE) can be a key element in reaching climate objectives. Similar to many other industrialized nations, Switzerland, in its Nationally Determined Contribution (NDC), commits to reducing greenhouse gas emissions (GHG) by 2030 to "*at least* 50% below 1990 levels" (NDC, 2020). In 2019, the transport sector was the biggest emitter of greenhouse gas (GHG) emissions in the country with 14.9 million tCO_2equiv. (32%), ahead of buildings (24%), industry (24%) and agriculture (14%). Within the domestic transport sector, road transport is responsible for almost all GHG emissions (14.6 million tCO_2equiv.) (Federal Office for the Environment (FOEN), 2021). Battery electric vehicles (BEV) are a readily available technology to decarbonize the transport sector. By now, consumers can choose from a wide range of different models from various manufacturers (Gersdorf et al., 2020). For some use cases, studies estimate a cost advantage of EVs over internal combustion engine vehicles (ICEV) in terms of lifecycle cost despite their higher upfront cost (Miotti et al., 2016). Unlike lifecycle emissions, lifecycle costs are difficult to determine because gasoline and electricity prices are volatile, whereas the emission intensity of the power grid and gasoline combustion can be predicted more easily (Verma et al., 2022). Yet, despite the estimated cost advantage and product availability, the current speed at which Swiss consumers adopt EVs remains insufficient to meet Swiss climate objectives.

Adoption of electric vehicles on the rise:

In 2020, the Swiss Road Traffic Office registered 336'800 new motorized vehicles across all vehicle segments in Switzerland. The two largest vehicle segments encompassed 238'700 new passenger cars and 32'430 new cargo vehicles (Federal Statistical Office, 2022). Here we focus on the passenger segment. In 2020, the new registrations in this segment plummeted by 23% compared to the 2019 level due to the outburst of the COVID-19 pandemic. However, in the same year, the number of new electric passenger cars on Swiss roads continued to rise to 19'800 vehicles (+49.8% compared to 2019). This EV growth was fueled by 19'800 BEV and 14'400 PHEV registrations. By the end of 2021, overall, new car registrations had not recovered from the COVID-19 shock yet, and new electric vehicle registrations continued to rise, with the growth rate of BEV overtaking PHEV (Federal Statistical Office, 2022). In Q4 2021, 19.5% of all new car registrations were BEVs; and 10.0% were PHEVs (Swiss Federal Office of Energy, 2022).

Reality has overtaken policy targets for electric vehicle adoption

Many European countries have adopted policy goals for the complete phase-out of new ICE vehicle registrations or sales, including Norway (2025), Sweden, Iceland, Ireland, the Netherlands, Slovenia (2030), Denmark and the United Kingdom (2035), France, and Spain (2040) (Wappelhorst, 2021; Wappelhorst & Cui, 2020). Unlike these countries, Switzerland has not adopted any national policy goal for the phase-out of ICE registrations or sales. Instead, the federal transport ministry initiated, in 2018, the "Roadmap Electromobility", a consortium of 50 public and private organizations. The aim was to increase the combined share of BEV and PHEV in all new passenger car registrations to 15% by 2022. Switzerland has passed this threshold already in Q3 2020, and efforts to introduce a new target for 2025 have not been successful yet (Swiss E-Mobility, 2021). Furthermore, Swiss eMobility, an association initiated by the Touring Club Switzerland (TCS) with a broad network of private-sector members across Switzerland, has raised ten demands in its "e-agenda 2021". When it comes to "emission-free individual mobility", Swiss eMobility demands that all new passenger car registrations be emissions-free by 2035 (Grossen & Hannesbo, 2021).

Role of beliefs concerning e-mobility

As highlighted by theories of consumer behavior, outcome expectations (i.e. perceived advantages and disadvantages of a product) are a major predictor of consumer attitudes towards a product. Attitude influences purchase intention, which in turn influences the actual purchase decision (Ajzen, 1991).

Perceived advantages and disadvantages of EVs over ICE vehicles are increasingly discussed by the general public. For example, news outlets such as Swissinfo, Handelszeitung, NZZ have published news series including "Mythbuster" to address common misconceptions concerning e-mobility. Likewise, automotive manufacturers have engaged in similar endeavors (e.g. Skoda's storyboard, Audi's e-Irrtümer).

The most common perceived concerns about electric vehicles deal with their lifecycle costs, lifecycle emissions, maximum range, charging times, battery ageing, availability of public charging, electricity grid impact, and environmental footprint of battery production.

Some consumers suspect that EVs may not reduce environment pollution because battery production and electricity generation may also cause pollution (Axsen et al., 2012). Such a belief could potentially decelerate vehicle electrification and jeopardize the emission goals in the transport sector. Environmental concern has been concluded the most studied factor towards EV adoption (Chu et al., 2019). However, other factors, such as mileage and refueling cost, might play a larger role in the purchase decision (Graham-Rowe et al., 2012).

Given the central role that beliefs play in the formation of EV purchase intention and purchase behavior, understanding potential EV users' beliefs concerning climate-friendliness of e-mobility helps design effective decarbonization policies for the transport sector.

Therefore, based on a consumer survey fielded in Switzerland in September 2021, we first assess the gap between experts' and the general public's views on emission break-even mileage of electric versus combustion vehicles. Then, we investigate potential drivers of heterogeneous beliefs concerning EV's climate-friendliness in the general public, and in particular the relationship between the perceived environmental friendliness of EVs (proxied by CO_2 break-even mileage perception) and purchase intentions.

Part 2: Estimating the climate friendliness of electric vehicles

Emissions for Electric Vehicles along their Lifecycle

In the production phase, EVs tend to accrue higher emissions than ICE vehicles due to the energy-intensive raw material extraction and production of the lithium-ion battery. In the use phase, EVs are characterized by lower emissions. The magnitude of their environmental advantage in the use phase depends on the carbon intensity of the electricity consumed at the point and time of charging. In the end-of-life (EOL) phase, EVs and ICE vehicles have similar emissions depending on recycling and reuse of the battery. As a result, an emission break-even mileage indicates what range an EV must drive to reach emission parity with a similar-sized ICE vehicle.

The emission break-even mileage has decreased continuously over the last years due to an increasingly energy-efficient production of lithium-ion batteries and a decreasing emission intensity of the electricity grid that results from large-scale RE deployment.

Diverging Experts' estimates of the Emission Break-Even Mileage

Various authors have calculated the emission break-even mileage for specific and stylized car models in Switzerland using the recent Swiss electricity mix. Generally, there is a wide range of estimates for that break-even point depending on the model assumptions (Bauer et al., 2015)(Bauer et al., 2015). A comparison of the emission intensity of battery electric driving in Switzerland (kg CO_2equiv. per km) across six different studies revealed that almost all estimate variability resulted from different assumptions about the battery production and EOL, while all authors used (almost) the same assumptions for road-associated emissions, grid emission intensity, and vehicle-associated emissions. Across the studies, the battery-associated emissions ranged from 20% to 60% of all BEV lifecycle emissions (Althaus & Bauer, 2011).

A recent study conducted by PSI & TCS suggested that the break-even mileage for mid-size cars was 26'851 km in 2020, with higher estimates for small cars and luxury cars. Other sources indicate that the emission break-even mileage might be as low as 10'000 to 20'000 km in 2022. Estimates are very sensitive to the chosen car model and the assumptions about the carbon intensity of lithium-ion battery manufacturing, which tends to decrease with mass manufacturing and decarbonization of the electricity mix (Ellingsen et al., 2016). A recent study even suggests that BEVs have a lower footprint in the production phase than ICE vehicles (Wolfram et al., 2021). Hence, there is a consensus that a large-scale replacement of ICE vehicles with EVs would ultimately reduce CO_2 emissions over the entire life-cycle of the car, and a majority of the literature assumes that EVs have higher initial emissions in the manufacturing phase which are then at some point overcompensated by lower emissions in the operating phase. Based on the review of existing studies and Swiss e-mobility experts' recent statements, we assume that a reasonable assumption for this point, the current emission break-even mileage, ranges between 20'000 and 30'000 km for passenger cars in Switzerland as of 2021.

Part 3: Analyzing Perceptions on Climate Friendliness of Electric Vehicles

General public's beliefs on Emission Break-Even Mileage:

We measured perceptions of climate-friendliness of EVs in Switzerland based on the responses of a consumer survey fielded in September and October 2021. The main sample ("representative survey") consists of 1'054 Swiss residents aged between 16 and 74 years residing in the German- and French-speaking region of Switzerland. It is representative in terms of gender, age, education and political orientation. In addition, the same questionnaire ("boost survey") was answered by 250 "early electrifiers", defined as people who, at the time of the survey, were owners of photovoltaic (PV) and/or EV, or intended to buy PV and/or EV within the next three years.

Among other questions, respondents were asked: "*For the CO_2 footprint of a car, production, transport, operation and recycling must be taken into account. After which distance travelled (in kilometers) do you think the CO_2 footprint of an electric car is better than that of a car with a combustion engine in Switzerland?*" We use responses to this question to measure citizens' beliefs on climate-friendliness of EVs in Switzerland.

We measured respondents' purchase intentions using a survey item inspired by Schwarzer's Health Action Process Approach (Schwarzer et al., 2008). Respondents were asked "Do you own or can you imagine owning an electric vehicle in the future?" Table 1 provides an overview of the possible answers to this question and their respective stage in the HAPA process.

Table 1: Allocation of stages in EV purchasing decision process and HAPA process

HAPA stages:	**Survey question: "Do you own or can you imagine owning an electric vehicle in the future?"**
Non-Intenders	"No, I haven't thought about it yet."
Intenders	"No, I don't own an EV but could imagine to purchase one in (select a year). – selected year must be between 2021 and 2024
Actors	"Yes, I already own an EV – and I purchased it in (select a year)" – selected year must be after 1990

In the representative sample, we identified 42 owners of an EV (4.0%) and 121 potential adopters (11.5%) who intended to purchase an EV within in the next three years. In the boost sample, we identified 36 actual owners (14.4%) and 105 potential adopters (42.0%).

The Health Action Process Approach for Adopting Electrical Vehicles

According to the Health Action Process Approach (HAPA), the process for changing one's behavior consists of at least a motivation and a volition phase (Schwarzer et al., 2008).

In the motivation phase, "non-intenders" become "intenders" by forming an intention to adopt a certain behavior. The precursors for forming a new intention encompass task self-efficacy, outcome expectancy, and – to a lesser extent – risk perception. In other words, individuals that form an intention to adopt a behavior change their beliefs in their capacity to execute behaviors to produce specific performance attainments (Bandura, 1997), they have a strong expectation of a specific outcome, and a good perception of relative risks associated with and without the behavior change. The intention-behavior gap refers to the phenomenon that once an individual has formed an intention, the intended behavior is not guaranteed, but depends on the volition phase.

In the volition phase, "intenders" become "actors" by translating their intention into action initiations and maintenance. The precursors are action planning and action control. In other words, individuals who initiate and maintain actions based on their intentions have planned when, where, and how they will act, and they have control mechanisms including self-monitoring at their disposal (Schwarzer et al., 2008)

While Schwarzer initially developed the HAPA model to predict and promote behavior changes in the health domain, such as abandoning unhealthy behaviors (e.g. quitting smoking) and adopting healthy behaviors (e.g. sports), other authors have applied the HAPA model successfully to other domains, such as sustainable consumption and the decision to invest in renewable energy (Hübner et al., 2012).

Key findings:

Figure 1 provides an overview of the perceptions of the emission break-even point between EVs and ICE vehicles prevalent in the Swiss population by HAPA groups. We find a relationship between the perceived climate friendliness of EVs and the adoption stage in the purchasing decision process (HAPA groups).

For the ***overall population***, we observe that the majority (54%) are EV optimists who hold slightly more positive beliefs of the climate friendliness of EVs than what current studies suggest is a realistic estimate – noting that these EV optimists might be ahead of their times if the production of EVs and the power grid continues to become greener. In contrast, 40% of respondents are EV pessimists. EV pessimists' estimates tend to be further off from the reasonable estimate than EV optimists'. Only 6% of the Swiss population provide answers within the 20'000 to 30'000 km range that appears to be the currently realistic estimate of the emissions break-even point.

For ***non-intenders***, who had not thought about purchasing an EV at the time of the survey, we observe by far the highest share of EV optimists (65%); and one of the lowest shares of EV pessimists (26%); and only few EV realists (4%). Non-intenders tend not to be well-informed, but their deviation is more tilted towards positive opinions on the climate friendliness of EVs.

For ***intenders***, who were planning to purchase an EV at the time of the survey, we observe significantly fewer EV optimists (42%), more EV realists (8%), and more EV pessimists (50%) than in the general population.

For ***actors***, who owned an EV at the time of the survey, the share of EV optimists was lowest (35%), the share of EV realists highest (14%), and the share of EV pessimists rather high (51%). Those who have moved from intention to action are the best informed segment, and to the extent that members of this group do not hold realistic beliefs, they are more likely to underestimate the climate friendliness of EVs.

Overall, the results show that non-intenders start out with fairly optimistic opinions about the climate friendliness of EVs. As consumers move from intention

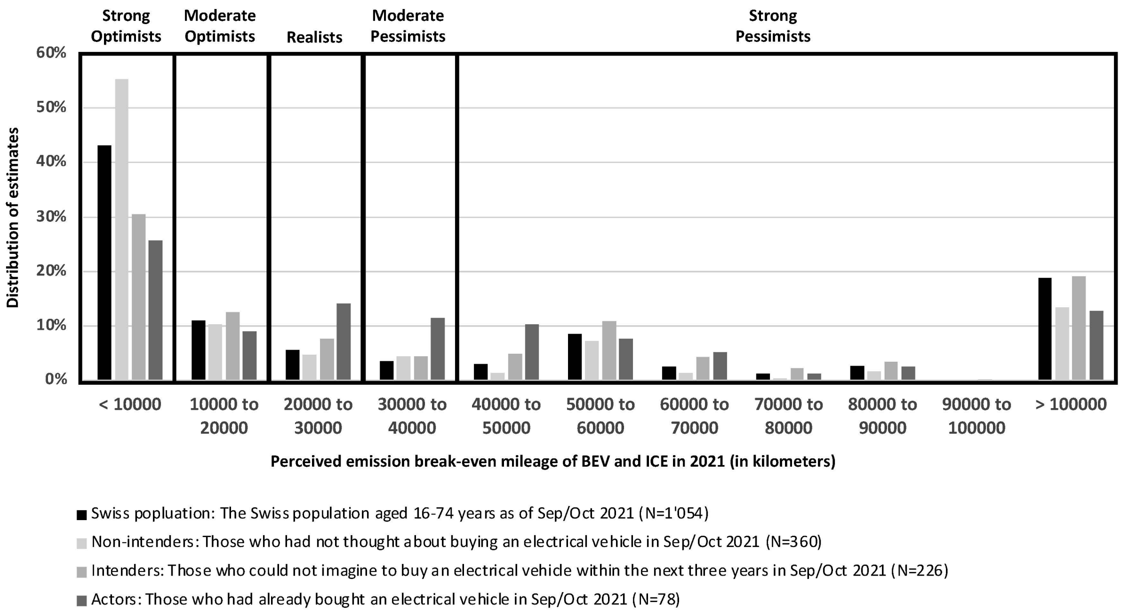

Figure 1: Perceptions of Emission Break-Even Mileage by HAPA groups

to action, they become better informed and somewhat less optimistic. Interestingly, this erosion of optimism regarding the climate friendliness of the product does not prevent them from making the purchase decision, perhaps suggesting that EVs are increasingly bought for other reasons than climate (alone).

Conclusion

We presented a case study of electrical vehicle adoption in Switzerland, conducted a literature research on the relative climate advantage of EVs compared to ICE vehicles, and analyzed the perceptions of the emission break-even point of EVs prevalent in the Swiss population at different stages of the purchasing decision process based on the HAPA model.

We find a relationship between the perceived climate friendliness of EVs and the stage in the purchasing decision process. At the pre-intention stage, people overestimate the climate friendliness of EVs and are poorly informed. As they enter the intention and action stage, they become less optimistic about the climate benefits of EVs and better informed. The results show that the erosion of EV climate optimism does not deter potential EV buyers from buying an EV, suggesting that EVs are bought out of other motives than just lowering emissions. The results corroborate the finding of other studies that information campaigns focusing on the environmental benefits of EVs alone are insufficient in accelerating EV adoption.

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The Hamada Beta Adjustment and the Cost of Capital for the Regulated Utilities

BY SCOTT LINN AND ZHEN ZHU

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I. Introduction

Despite many issues with the Capital Asset Pricing Model (CAPM), it is still one of main methods that is used to estimate the expected rate of return on equity for regulated utilities in rate proceedings in the United States. A primary underpinning of the model is that investors require compensation for bearing undiversifiable systematic risk. A product of the theory is that the degree of systematic risk (beta risk) an investor bears for investing in any equity security is measured by how closely the stock's price changes (returns) covary with the overall market, proxied by the returns on a market index. The expected cost of equity is the sum of two parts: a risk-free rate and a risk premium which is the product of the beta of the company's stock and a market risk premium. A key ingredient of course is the stock's beta, which depends upon the nature of the business as well as how the business is financed. Our focus in this note is on the latter relation between beta and how a company is financed (specifically the debt/equity ratio), and how this relation if not considered correctly can lead to incorrect estimates of a company's required return on equity, and consequently to incorrect rate adjustments.

Technical Box A: CAPM

$$R = R_f + \beta\,(R_m - R_f),$$

Where R is the required or expected return on equity for the utility, R_f is the risk-free rate, β is the company beta, and R_m is the market return. $(R_m - R_f)$ is the market risk premium.

In the practice of a rate proceeding, various methods have been utilized to model each of the three components of the CAPM: the risk-free return, the market risk premium, and the beta. Some rate-setting commissions have specific requirements regarding how to model each component. For example, the Federal Energy Regulatory Commission (FERC) requires the risk-free interest rate to be a long-term Treasury Bond yield, the company stock beta is the beta value provided by Value Line, and the market risk premium is measured by the difference between the market return based on a one-step DCF model applied to the dividend paying S&P 500 companies and the risk-free rate. The rules however are not uniform across state commissions, so that an estimate in one jurisdiction could potentially deviate from an estimate in another for the same company. At the same time there has been increasing advocacy for methods designed to adjust beta. The point of this note is to consider one such adjustment and to highlight how that adjustment can lead to a biased estimate of a company's beta and hence the required return on equity.

Theory tells us that beta as generally measured, is under certain conditions, positively related to the company's debt to equity ratio, where the ratio is measured using the total market values of a company's debt and equity. It is important to recognize that the beta computed by most popular commercial services, such as Value Line and Bloomberg, is based upon market returns. What does this mean? Specifically, the returns on a stock are based upon the assessment by capital market participants of changes in the stock's value which are then reflected in changes in its market price. Changes in valued reflect market participants' interpretation of fundamental information about the company, including how it is financed. The market value debt to equity ratio reflects the extent to which the shareholders share the total value of the company with the debtholders, and hence the shareholders' exposure to debt financing. Recognize that the total value of a company equals, in usual parlance, the total market value of the debt and equity, which would only by accident equal the book value of debt plus the book value of equity. In other words, market participants know this information and condition changes in prices on knowledge of a company's market value debt to equity ratio.

Hence, the implied cost of capital, whether the equity required return or the weighted average cost of capital, is a number based upon the market values of debt and equity not book values.[1] This leads us to an important issue confronting rate setting commissions. One common practice on the side of the ROE requesting utilities is to use what is commonly referred to as the Hamada equation to make an adjustment to the beta value obtained from an investment service. The argument for this so-called leverage adjustment is that the capital structure use in calculating the weighted average cost of capital is based on book value but the return on equity is based on the market value, and in addition, the rate base is based on book value.

Setting aside how the weighted average cost of capital is computed, whether using book value or market value weights, we explore the implications of adjusting beta using the book value versus market value debt to equity ratio. As the market value of most utility's equity nowadays is typically higher than the book value of the equity, the book value debt ratio will typically be larger than if the market value debt/equity ratio is employed. As the beta computed using market returns reflects the market debt/equity ratio, if instead it is adjusted to conform to a book value debt/equity ratio, the resulting beta will be larger than the observed beta provided by say Value Line. Such an adjustment would lead to higher beta values and thus a higher calculated expected rate of return on equity given the estimate of the risk-free rate and the market risk premium.

II. What is the Hamada equation?

Professor Hamada, once the dean of the famed Booth College of Business at the University of Chicago, was the first to derive the relation between a company's stock's beta and the company's market value debt/equity ratio. Specifically he shows that beta increases as the market debt/equity ratio increases. Hamada defines two different betas for a company's stock. One beta is what we usually obtain from the investment services such as Value Line, and this beta is called the levered beta as it is derived from the market data reflecting the company's existing capital structure, that is, its market value debt/equity ratio. In contrast, suppose the same company used no debt financing, then the corresponding beta would be what we would observe for an unlevered (no debt financing) company, and is typically referred to as the unlevered beta. The levered beta exceeds the unlevered beta which the company uses debt financing. Note that all terms are measured in market values.

The equation shown nearby shows how a company's beta changes as the company's market value debt/equity ratio changes. The higher the market value debt/equity ratio (leverage), the higher the financial risk and thus the higher is beta. For example, if a company's unlevered beta is 1.0, the market value debt/equity ratio is 0.5, and the marginal tax rate is 21%, then the levered beta would be 1.395, an increase of 39.5%.

Technical Box B – The Hamada Equation:

$\beta_L = \beta_U * [1 + (1-t)\ D/E]$,

where β_L is the levered beta, which measures the firm's systematic risk with the impact of debt and β_U is the unlevered beta, which measures the firm's systematic risk without the impact of debt, t is the marginal tax rate, D/E is the company's debt-to-equity ratio which measures the company's financial leverage.

The beauty of the Hamada Equation is that it can be used to infer what a company's beta would equal for any assumed debt/equity ratio, including what an analyst might argue is the debt/equity ratio that goes with an 'optimal' capital structure for the company.[2] The process of finding a new levered beta involves what is often referred to as first unlevering and then relevering. The starting levered beta is observed by consulting an investment service such as Value Line. The unlevered beta is not directly observable but can be backed out of the Hamada formula if other information such as the tax rate and an estimate of the market value debt ratio are available. This process is called unlevering. The unlevered beta can then be relevered to obtain the new levered beta estimate that is conditional on an assumed debt/equity ratio which could be the one that goes with the optimal capital structure. This process of course makes the explicit assumption that the current debt/equity ratio is not what is desired and that shortly in the future the company will rearrange its financing to reflect a better mix and a new debt/equity ratio.

Take the example of finding the beta for a company's stock assuming the current debt/equity ratio is not the best but the analyst believes she knows what the best debt/equity ratio equals. Suppose the current observable beta or levered beta is 0.8 for a utility that has a debt ratio of 1.25. With a tax rate of 0.21, the unlevering process would generate an unlevered beta of 0.40. Conceptually, if the company used no debt financing the beta would be 0.40.

Suppose the optimal capital structure is 50% debt and 50% equity, so the debt-to-equity ratio would equal 1.0, then the relevered beta would equal 0.716. Specifically with the optimal capital structure, the company's beta would equal 0.716, a value less than the current levered beta value of 0.8.

Two important assumptions underlying the Hamada equation are first that the beta of the company's debt is zero, and second that the CAPM model is valid.

III. How is the Hamada equation used to adjust the beta in rate proceedings?

Sometimes, the Hamada equation is used in rate proceedings to adjust the unlevered beta using the book value debt/equity ratio. If the book value of equity is less than the total market value of equity, which is typical nowadays, this will lead to a beta that is inflated more than it should be, and consequently a required return on equity computed using the CAPM that is larger than it should be. The argument goes that such a "book value leverage adjustment" is necessary because the required rate of return on equity will be used to compute a weighted average cost of capital using weights based upon the book values of debt and equity. According to advocates of this suggested adjustment, beta based on a market value capital structure mis-represents the financial risk of the company, and therefore, the conventionally available betas cannot be used directly in the CAPM, unless the cost of equity developed using these betas is applied to the computation of a weighted average cost of capital in which the weights are based upon market values. The market value capital structure of a utility and the company's book value capital structure typically are not the same. The argument that , there is a need to make the so-called leverage adjustment to adjust the beta to reflect the utility's risk based on book value capital structure, is simply incorrect as true risk is not based upon historic book values. The reason is that the book value of the assets of the company is not a true reflection of the assets' market value and it is the market value of the assets which indicates the true support for the company's debt.

The following example illustrates how the Hamada equation used incorrectly leads to a cost of capital that is too large.

Assume a utility with a market value debt/equity ratio[3] of 0.8 has a Value Line reported beta of 0.75. Suppose the company's marginal tax rate equals 21% , then the company's unlevered beta can be computed as shown earlier, and will equal 0.46.

Utility total equity market values are usually significantly higher than the book values, leading to a significantly higher book value debt/equity ratio than would be the case for the market value debt/equity ratio. This comparison is typically the reason why some analysts claim that the financial risk represented by the book value is higher than the financial risk represented by the market value.[4] But this is inherently a flawed argument as we have just commented.

Assume for our example company that the book value debt/equity ratio is 1.0. The unlevered beta value of 0.46 is then relevered by the book value capital structure to arrive at an adjusted estimate of beta that would for our illustration, equal 0.82, a 9% increase in the beta to be used in the cost of capital calculation

The book value relevered beta value when used in the CAPM model will therefore lead to a required return on equity that is larger than it should be.

IV. Is the Hamada adjustment reasonable?

In summary we repeat the limitations of the book value debt/equity adjustment process as well as a more general limitation of the Hamada model.

First, unlike the process of unlevering and relevering the market value beta to obtain a levered market value beta that reflects the optimal market value capital structure, relevering the market value unlevered beta using the book value debt/equity ratio, yields a beta estimate that cannot be interpreted, and therefore cannot legitimately be used in the estimation of the cost of capital in the CAPM model.

Second, the Hamada adjustment process assumes, even if we are using the correct market value deb/equity ratio, that the beta of the company's debt is zero. This assumption is simply not strictly met, although academic studies that present estimates of bond betas generally find that they are small but nevertheless positive.[5] Thus the formula is invalid for any levering or unlevering operations in general if the company's debt beta is not zero or the risk is systematic[6].

V. Conclusions

We have demonstrated in this short note what the Hamada leverage adjustment is and how it should be applied. We also pointed out that one of the applications of this formula is in the context of capital cost estimation in the rate case proceedings for public utilities. That application involves an adjustment based upon the book values of debt and equity of the utility. We illustrate how such an adjustment leads to an incorrect estimate of the beta used in the Capital Asset Pricing Model formula, which in turns leads to an estimated required return on equity that is too large. While this adjustment is used to justify the higher requested return on equity by utilities, this is an incorrect use of the Hamada equation adjustment. We have pointed out the invalidity of the adjustment process using book values for debt and equity as the theory underlying the Hamada equation requires a debt/equity ratio based upon market values. In other words, if the adjustment is to be correct there is no room for the use of book values.

Many analysts in the past rate proceedings have pointed out various issues with the application of the Hamada leverage adjustment; however, to our knowledge, there is no clear demonstration of how this Hamada leverage adjustment application is invalid in its process. It is our hope that practitioners engaged in the estimation of utility cost of capital recognize the issues we raise and the biases that can arise from the incorrect application of the Hamada adjustment. Our second objective with this note is to inform the many jurisdictional authorities faced with the task of deciding on rate adjustments of the potential biases we have highlighted. Perhaps, these decision makers have recognized the potential problems we outline as no such Hamada adjustment has yet been allowed in any utility rate proceedings to our knowledge. However, this is not to say that cost of capital witnesses have not been advocating the type of book value debt/equity adjustment we have illustrated which makes the information we provide both timely and of potentially important. In our opinion, due to its lack of theoretical support and the upward bias it introduces, the idea of making the so-call book value leverage adjustment to beta should be put to rest.

Footnotes

[1] The general practice in the rate making process, however, is to use book value capital structure in weighting the cost of capital, for some reasons, see, for example, Roger A. Morin, New Regulatory Finance, Public Utilities Reports, Inc., 2006, page 452. This has been another important and interesting issue in the practice. However, it goes beyond the scope of this note.

[2] We do not take up the issue of what an 'optimal' capital structure might be for any particular utility. Some argue this can be inferred by looking at industry averages, but that presumes the industry participants are themselves choosing optimally. Needless to say, the concept of what is an optimal capital structure is by no means a resolved issue.

[3] The market value of equity can be based on the market capitalization. Utility debt instruments are frequently not traded and so do not have observable market prices. However, under current reporting requirements, fair value estimates of a utility's debt can be obtained from the utility's 10K report.

[4] Again, the notion of two different financial risks is dubious as a company cannot have two different measures of financial risks that are not the same.

[5] See a study of bond returns by Backaert and De Santis, "Risk and return in international corporate bond markets", Journal of International Financial Markets, Institutions & Money, Vol. 72, 2021.

[6] By systematic we mean that the returns on the bond vary with the returns on a market index the way the returns on a stock vary with an index. Conine demonstrated that the Hamada formula is not compatible with the assumption of issuing risky debt. See Conine, T. (1980) Corporate Debt and Corporate Taxes: An Extension. The journal of Finance, 35(4), 1033-1037.

44th IAEE INTERNATIONAL CONFERENCE
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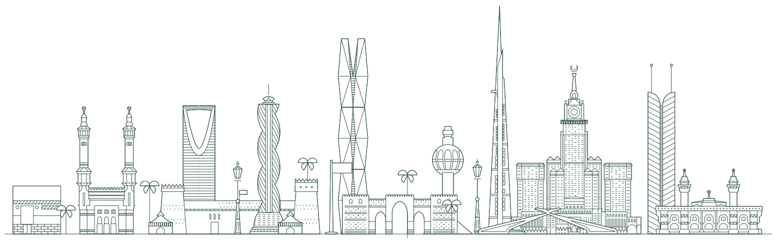

Call For Papers

Pathways to a Clean, Stable, and Sustainable Energy Future

The Saudi Association for Energy Economics (SAEE) and the King Abdullah Petroleum Studies and Research Center (KAPSARC) are hosting the 44th International Conference of the International Association for Energy Economics (IAEE) on February 4-8, 2023, in Riyadh, Saudi Arabia.

Conference Overview

Tackling climate change while ensuring a just, reliable and clean energy transition has been at the forefront of global challenges. The onset of COVID-19 has further exacerbated the challenge of meeting climate targets. The 2021 United Nations Climate Change Conference (COP26) urged further actions by Parties to reduce their carbon dioxide (CO2) emissions by 2030 so that the world could reach net-zero emissions by 2050. As the world slowly recovers from the aftermath of the pandemic, millions of people still lack access to affordable, reliable, and sustainable energy and clean cooking. The 44th IAEE conference will highlight the interdependence of clean, stable, and sustainable energy trajectories. In addition, recent developments in energy markets will be discussed. For more information kindly visit https://iaee2023.saudi-aee.sa

This will be the first time that the IAEE has held its international conference in the Middle East and North Africa (MENA) region, one that, for the past two decades, has supplied the world with more than 40% of its oil and gas needs. The region's hydrocarbon production potential and cost advantages will affect and be affected by the pattern and speed of the global energy transition.

The 44th IAEE International Conference will provide an opportunity for government officials, institutional leaders, academics, and corporate leaders to meet, exchange views and address timely and relevant issues facing the energy sector.

Program Structure

The program will feature keynotes, workshops, plenaries and concurrent sessions. These will include Hydrogen and Circular Carbon Economy (CCE) Workshops. The following Energy Plenaries are planned:

- Economy and Energy Diversification in MENA
- Energy, Development, and Climate Change
- Energy Transition and Pathways
- Investment and Financing
- Mobility and Technology
- Efficiency and Industrial Competitiveness
- Energy Volatility, Security, and Access

The program also features a tour and dinner at a world heritage site, dinner at the National Museum featuring Arabian prehistory, history, culture, and art as well as optional technical tours.

Call for Papers

Concurrent session presenters must submit an abstract that briefly describes their research or case study. Along with the overview, it must include the background and potential significance of their research, its methodology, results, conclusions, and references (if any). All abstracts must conform to the structure outlined in the abstract template. Abstracts are limited to no more than two pages in length and must be submitted online no later than September 9, 2022.

IAEE International Association for Energy Economics

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Conservation of the Global Environment by Developing Digital Platforms – As a Preliminary Perspective

BY MASAO TSUJIMOTO

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Abstract

This paper explores environment conservation with development of digital platforms, employing financial performance and environmental impact data from six digital platform providers in the US and Japan. [1]

1. Introduction

This paper explores conserving the global environment while promoting the sustainable development of digital platforms. It uses financial performance and environmental impact data of six digital platform providers in the US and Japan.

First, amid the COVID-19 pandemic, the challenge of achieving conservation while developing digital platforms has become increasingly urgent for platform providers such as Google, Amazon, Facebook (newly named Meta Platforms), and Apple (GAFA), Rakuten, and Yahoo Japan.

Despite its importance, the author's thorough review of academic journals reveals that minimal research has been conducted from this paper's trans-Pacific perspective and accounting approach. The lack of prior research is assumed to be due to a lack of data related to insufficient disclosure of ESG information and inconsistency in company and rating agency standards.

Therefore, this paper clarifies the results of the regression analysis and discusses the fact that the efforts to develop digital platforms while preserving the global environment have reached the beginning of the germination stage of decoupling growth and environmental impact.

2. Legislation and Trends for Environmental and Digital Goals in Japan

This section outlines the progress of legislation on global environmental conservation and digital platform development in Japan and summarizes business expansion and potential power shortages for digital platforms. This highlights two Japanese platforms, in addition to GAFA, because it will offer useful information for overseas researchers to focus on the legislative progress of global warming prevention and digital platforms in Japan; the U.S. legal system was omitted due to word limit.

First, in October 2020, the Japanese government committed to attaining a carbon-neutral society by 2050 to comply with the Paris Agreement and raised its target for reducing greenhouse gas emission from 26% to 46% against 2013 levels by the target year 2030 in April 2021.

Moreover, Act (No. 117 of 1998) on Promotion of Global Warming Countermeasures was revised in May 2021. The term *control* of greenhouse gas emissions in the previous Act was strengthened using the word *reduce.* Article 5, for example, highlights the need for companies' cooperation with national and local governments as follows, "Business entities shall endeavor to take measures to *reduce* greenhouse gas emissions and shall cooperate with measures implemented by the national and local governments to *reduce* emissions."

Furthermore, two complementary Acts specifically related to digital platforms were ratified in Japan: Act (No. 38 of 2020) on Improving Transparency and Fairness of Digital Platforms (official abbreviation: TFDPA) in May 2020 and Act (No. 32 of 2021) for the Protection of Users of Digital Platforms in April 2021.

In the TFDPA, Article 2, Paragraph 1, and Paragraph 5 define *digital platforms* and *digital platform providers* as follows:

Digital platforms refer to services provided to many persons through the internet or other advanced information and telecommunications networks. Information regarding goods, services, or rights of persons who intend to present offers is usually displayed.

Digital platform providers refer to entities that provide online platforms alone or in collaboration.

Cabinet Order No. 17 of 2021 establishes the scale of specified digital platform providers subject to the TFDPA.

- *B to C comprehensive online mall providers:* Total domestic circulation in the previous fiscal year of 300 billion yen ($264 million) or more.
- *B to C application store providers:* Total domestic circulation in the previous fiscal year of 200 billion yen ($176 million) or more.

In accordance with Cabinet Order No. 17 of 2021, the six entities in Table 1 have been designated as *specified digital platform providers.* This includes Japanese subsidiaries of (1) Amazon, (4, 5) Apple, and (6) Google from the US as well as the domestic platforms (2) Rakuten and (3) Yahoo

Table 1 Specified digital platform providers

Comprehensive online shopping malls	
Company names	Names of malls
(1) Amazon Japan G.K.	Amazon.co.jp
(2) Rakuten Group, Inc.	Rakuten Ichiba
(3) Yahoo Japan Corporation * Subsidiary of Z Holdings	Yahoo! Shopping
Application stores	
Company names	Names of stores
(4) Apple Inc. (5) iTunes KK	App Store
(6) Google LLC	Google Play Store

Source: Ministry of Economy, Trade and Industry of Japan

Japan. A Japanese subsidiary of Meta-Facebook is not designated because it does not meet the specified scale in Japan.

Moreover, the Digital Agency, headed by the Minister, was newly established in September 2021 to promote the formation of a digital society by collectively managing the operations divided among various Ministries.

Therefore, the legal framework for global environmental conservation and digital platform development is in progress.

However, there is room for further reforms in protecting personal information, preventing "fake news" and abusing monopolistic market power, and improving corporate governance structure.

On the other hands, the growing scale and influence of digital platform providers have made the issue of balancing platform development and conserving the global environment more urgent.

Consolidated sales performance has been on the rise for the six digital platform providers in this study, GAFA, Rakuten, and Z Holdings (100% shareholder of the designated Yahoo Japan). According to each company's financial statements, GAFA's total sales reached $773.2 billion in 2019 and $923 billion in 2020, up 19.4% year on year, and all six platforms combined reached $794.5 billion in 2019 and $941 billion in 2020, up 18.5% (see "References"). The sales of GAFA and all six digital platforms in 2020 were nearly equivalent to Netherlands' nominal GDP of $909 billion. (IMF 2021). GAFA's market capitalization ($7.43 trillion) at NASDAQ in the middle of January 2022 exceeded to that of all 3,823 companies listed on the Tokyo Stock Exchange ($6.95 trillion).

Regarding Monthly Active Users (MAU) in 2021, Facebook reached 2.91 billion globally as of September 30, 2021, an increase of 6% year-over-year (Facebook 2021c). In July 2021 in Japan, Yahoo was first with 85.92 million; Google in second, with 82.18 million; LINE (another subsidiary of Z Holdings) third, with 71.00 million; YouTube fourth, with 69.71 million; Rakuten fifth.[2]

Notably, GAFA combined emitted 93.13 million tons in 2019 and 95.30 million tons of CO_2 (market basis) in 2020, up 2.3%. And the six providers, including Rakuten and Z Holdings, emitted 97.63 million tons in 2019 and 101.11 million tons in 2020, up 3.6%, which is nearly equivalent to Qatar's 99.49 million tons in the same year (EDGAR website).

Japanese government reports have sounded the alarm regarding the insufficient power supply and network infrastructure capacity during the COVID-19 outbreak and subsequent restrictions on the development of digital platforms. For example, the Ministry of Internal Affairs and Communications (MIC, 2021) reported that the traffic of fixed-line broadband service subscribers in Japan was on the rise in May 2021, with downloads increasing 25.6% to 23.9 Terabits per second (Tbps) and uploads increasing 19.8% to 2.8 Tbps year on year. Japan Science and Technology Agency (JST 2021) reports propose concerted energy conservation at data centers, as power consumption in Japan will be 90 TWh in 2030 and 12,000 TWh by 2050, compared to 14 TWh in 2018, with the spread of cloud services, medical image diagnosis, and face recognition.

The Tokyo Metropolitan government has adopted a data center evaluation system, revealing that Power Usage Effectiveness (PUE) averaged 1.91 at the 78 locations measured. (The closer the value is to 1.0, the more efficient it is.) However, considerable improvement is needed. Google, considered one of the best data centers, had an average annual PUE of 1.10 in 2020 (2021a, p. 4). Hence, the issue has become urgent to environmental conservation in promoting the development of digital platforms.

3. Method, Results and Discussion

This section verifies the relationship between the six digital platform providers' financial and environmental impact data, employing linear, quadratic, and cubic regressions. This approach differs from previous studies in using data from platform providers in both the US and Japan. The method is outlined below.

- The six target platform providers:

GAFA (Google, Amazon, Meta-Facebook, and Apple), Rakuten, and Z Holdings. This paper includes Facebook, which is not *designated* by TFDPA in Japan, in the analysis given GAFA's overall name recognition and influence. The six providers analyzed in this paper differ from the six presented in the TFDPA in Table 1. And consolidated data are examined because non-consolidated environmental data are not disclosed in detail.

- Dependent and Explanatory variables:

The number of basic regression formulas includes 20 combinations of 4 x 5. The number of advanced formulas is 35 by 7 x 5 because each item decomposed in Scopes 1, 2, and 3 is tested in addition to total CO_2 emissions in Table 2.[3]

- Target year of data:

Cross-section data is for the year 2020.

Available environmental impact data before 2019 is insufficient or inconsistent, rendering time series analysis impossible in prior studies.

For example, Google (2020) says, "to align with industry best practices for Scope 3 reporting. We extended our reporting boundaries." Thus, Google's Scope 3 CO_2 emissions in 2019 were 4.29 times higher than that reported in 2017 (p.79). The extension of the range suggests that the measurement method used before 2017 was insufficient.

Table 2 Dependent and Explanatory variables (abbreviation)

Dependent variables: Basic - 4, Advanced - 7	Explanatory variables: 5
(1) CO_2 emissions (CO_2, million MT) • Total = Scope 1 + 2 + 3 emissions • Scope 1 (SCP1, million MT) • Scope 2 (SCP2, million MT) • Scope 3 (SCP3, million MT)	(1) Net sales (SAL) (2) Net income (INC) (3) Earnings per share (EPS) (4) Total assets (TAS) (5) Property, plant, and equipment (PEQ)
(2) Electricity consumption (ELC, MWh)	
(3) Water consumption (AQU, m³)	
(4) Waste generation (WST, tons)	

Though the data is limited to 2020, it illustrates the circumstances of each company amid the COVID-19 pandemic, which discloses certain implications, prospects, and germination in the relationship between conservation and development for digital platforms.

By employing the Environmental Kuznets Curve (EKC) hypothesis, the author has already calculated and derived the following preliminary results and findings.

The EKC hypothesis is an economic theory that illustrates the relation between growth and environment impacts. This is an application of the theory of economic growth and income inequality postulated by Dr. Simon Kuznets, a Nobel laureate in economics. In the hypothesis, environment impacts increase up to a certain level of economic growth, and then start to decrease, showing an inverted U-shaped curve at the turning point.

(1) Results: The regression analyses illustrate a monotonic increase in the seven cases out of thirty-five tested, while the EKC hypothesis is confirmed in the two combinations of Electricity consumption (ELC)–Earnings per share (EPS) (Figure 1), and an Inverted N-shaped curve, a variant model of the EKC hypothesis, is demonstrated in the cubic regression of Scope 2 CO_2 emissions–Earnings per share (Figure 2).

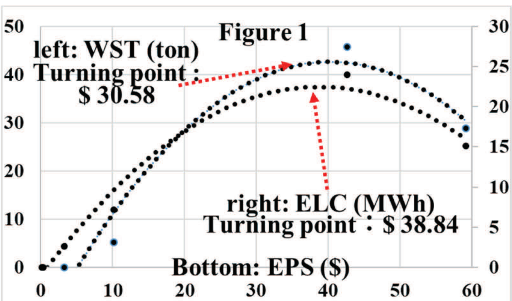

FIGURE 1
Electricity consumption (ELC) / Waste generation (WST) – Earnings per share (EPS)

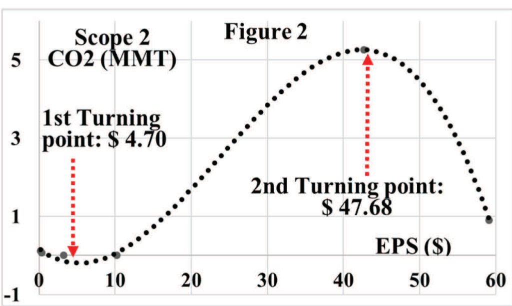

FIGURE 2
Scope 2 CO_2 emissions–Earnings per share

(2) findings: regarding the significant cases confirmed in the EKC hypothesis and the inverted N-shaped curve, the growing trend of Environment, Society, and Governance (ESG)-oriented investment has acted as competitive pressure on the platform providers for fundraising, especially in spurring them to disclose information.

Investors' emphasis on ESG has been functioning as the compelling or driving force to advance digital platform providers' implementation of ESG-related environmental conservation activities, particularly in terms of information disclosure, through financing requirements, such as loans and underwriting of securities and bonds.

On other hands, without appropriate disclosure of ESG information, digital platforms face challenges in raising funds through the issuance of bonds and securities. In addition, disclosure requires the formulation and execution of corporate strategies that are worthy of disclosure, and the promotion of ESG activities, such as participation and signature on various ESG initiatives. Furthermore, data is disclosed on sponsoring organizations' websites regarding whether the providers signify and the attending ratings. As a result, the platform providers are driven to compete with rivals for information disclosure, as if the dominoes are beginning to fall.

4. Concluding remarks

Digital platform providers that have become so powerful today can offer spaces for sharing and interaction through their platforms and meaningfully contribute to the realization of a sustainable society, represented by *No. 13: Climate Action* of the 17 United Nations Sustainable Development Goals. Digital platform providers must strengthen internal efforts to collaborate with Scope 2 and 3 business partners through knowledge sharing to advance a sustainable society.

Therefore, establishing the EKC hypothesis and the Inverted N-shaped curve in this research indicate the beginning of the *germination* stage of decoupling growth and environmental impact. All economic actors must advocate that digital platform development presents a driving force for global environmental conservation, taking advantage of the current state of economic and social transformation.

Footnotes

[1] This is a preliminary summary to be presented in a forthcoming paper at the International Association for Energy Economics (IAEE) 2022 Conference in Tokyo.

[2] The other rankings in Japan are: seventh, Twitter, with 51.99 million; eighth, Instagram, with 47.71 million. Apple and Facebook were in the top 10 until 2020, but in this data, they are below the top 10.

[3] Basic formula are:

$Y(CO_2) = \alpha + \beta_1 (SAL) + \varepsilon,$

$Y(CO_2) = \alpha + \beta_{11} (SAL) + \beta_{12} (SAL)^2 + \varepsilon,$

$Y(CO_2) = \alpha + \beta_{11} (SAL) + \beta_{12} (SAL)^2 + \beta_{13} (SAL)^3 + \varepsilon.$

The significance level of the p-value is set at 5% ($p < 0.05$). α and ε indicate constant and error terms, respectively.

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IAEE/Affiliate Master Calendar of Events

(Note: IAEE Cornerstone Conferences are in boxes)

Date	Event and Event Title	Location	Supporting Organizations(s)	Contact
2022				
July 31-August 3	43rd IAEE International Conference *Mapping the Global Energy Future: Voyage in Unchartered Territory*	Tokyo, Japan	IEEJ/IAEE	Yukari Yamashita https://iaee2022.org/
September 21–24	17th IAEE European Conference *The Future of Global Energy Systems*	Athens, Greece	HAEE/IAEE	Spiros Papaefthimiou http://haee.gr/
October 24-26	39th USAEE/IAEE North American Conference *Theme TBD*	Houston, Texas	USAEE/IAEE	Doug Conrad usaee@usaee.org
November 20–22	8th Latin American Energy Economics Conference	Bogota, Colombia.	ALADEE	Gerardo Rabinovich grenerg@gmail.com
2023				
February 4-9	44th IAEE International Conference *Energy Market Transformation in a Globalized World*	Saudi Arabia	SAEE/IAEE	Majid Al-Moneef moneefma@gmail.com
July 17-20	18th IAEE European Conference *The Global Energy Transition: Toward Decarbonization*	Milan, Italy	AIEE/IAEE	G. Battista Zorzoli https://www.aiee.it/
2024				
June 23-26	45th IAEE International Conference *Overcoming the Energy Challenge*	Istanbul, Turkey	TRAEE/IAEE	Gurkan Kumbaroglu http://www.traee.org/
2025				
June 22-26	46th IAEE International Conference *Title TBA*	Paris, France	FAEE/IAEE	Christophe Bonnery https://www.faee.fr
2026				
May-June	47th IAEE International Conference *Forces of Change in Energy: Evolution, Disruption or Stability*	New Orleans	USAEE	Peter Balash www.usaee.org

Calendar

05-08 July 2022, Carbon Capture, Utilisation and Storage (CCUS) at Live Online Course. Contact: Phone: +6563250215, Email: abigail@infocusinternational.com URL: https://www.infocusinternational.com/ccus

18-19 July 2022, Reuters Events: US Offshore Wind 2022 at Hynes Convention Center, 900 Boylston Street, Boston, Massachusetts, 02115, United States. Contact: Email: Diana.Dropol@thomsonreuters.com URL: https://go.evvnt.com/947561-0?pid=204

19-21 July 2022, Advancing Construction Decarbonization 2022 Conference | July 19-21, Chicago, IL at Hotel Chicago Downtown, Autograph Collection, 333 North Dearborn Street, Chicago, Illinois, 60654, United States. Contact: Phone: +(1) 713 554 8380, Email: info@hansonwade.com URL: http://go.evvnt.com/1055931-0?pid=204

July 31 - August 03 2022, 43rd IAEE International Conference - Mapping the Global Energy Future: Voyage in UncharteredTerritory at Tokyo, Japan. Contact: URL: www.iaee2022.org

02-02 August 2022, X International Academic Symposium: Green Opportunities for the Energy Sector at Barcelona. Contact: Email: ieb.simposium@ub.edu URL: https://ieb.ub.edu/ca/inicio/catedra-de-sostenibilidad-energetica/

02-02 August 2022, X International Academic Symposium: Green opportunities for the energy sector at Barcelona. Contact: Email: ieb.simposium@ub.edu URL: https://ieb.ub.edu/ca/event/x-international-academic-symposium-green-opportunities-for-the-energy-sector/

25-26 August 2022, International Conference on Green Technology and Environmental Science at Thailand. Contact: Phone: +667448808243, Email: greentech.conference@gmail.com URL: https://unitedresearchforum.com/environmentalscience-conference/

06-07 September 2022, SPE Workshop: Well Integrity in a Changing World, 6-7 September 2022, The Netherlands at Leonardo Royal Hotel Den Haag Promenade, 1 Van Stolkweg, Den Haag, Zuid-Holland, 2585 JL, Netherlands. Contact: Email: vrcarril@spe.org URL: https://go.evvnt.com/909171-0?pid=204

08-09 September 2022, SPE Workshop: Production Optimisation in Gas and Oil Assets, 8-9 September 2022, The Netherlands at Leonardo Royal Hotel Den Haag Promenade, 1 Van Stolkweg, Den Haag, Zuid-Holland, 2585 JL, Netherlands. Contact: Email: kdunn@spe.org URL: https://go.evvnt.com/911491-0?pid=204

12-13 September 2022, 8th Annual IOT in Oil & Gas Conference at Hilton Americas-Houston, 1600 Lamar Street, Houston, Texas, 77010, United States. Contact: Phone: 18558694260, Email: symon.rubens@energyconferencenetwork.com URL: https://go.evvnt.com/1018143-2?pid=204

21-24 September 2022, 17th IAEE European Conference: The Future of Global Energy Systems at Athens, Greece. Contact: URL: www.haee.gr

22-22 September 2022, World Energy Storage Day at Virtual. Contact: Phone: India, Email: dsalunkhe@ces-ltd.com URL: www.energystorageday.org

11-13 October 2022, SPE Russian Petroleum Technology Conference at Pokrovka St, 47, 47 Pokrovka Street, Moskva, 105064, Russia. Contact: Phone: +74952680454, Email: lkhalmuradova@spe.org URL: http://go.evvnt.com/1033804-0?pid=204

19-20 October 2022, Hydrogen Technology Conference and Expo at Bremen Exhibition Hall 5, 101 Hollerallee, Bremen, 28215, Germany. Contact: Phone: +441483330018, Email: charlie.brandon@trans-globalevents.com URL: http://go.evvnt.com/1037774-0?pid=204

19-20 October 2022, Carbon Capture Technology Conference & Expo at Bremen Exhibition Hall 5, 101 Hollerallee, Bremen, 28215, Germany. Contact: Phone: +44 1483330018, Email: charlie.brandon@trans-globalevents.com URL: https://go.evvnt.com/1037764-0?pid=204

09-10 November 2022, Reuters Events: Energy Transition North America 2022 at TBC, Houston, TX, United States. Contact: Email: owen.rolt@thomsonreuters.com URL: https://go.evvnt.com/1093186-0?pid=204

05-08 February 2023, 44th IAEE International Conference: Energy Market Transformation in a Globalized World at Riyadh, Saudi Arabia. Contact: Email: moneefma@gmail.com URL: www.iaee.org

23-26 June 2024, 45th IAEE International Conference, Overcoming the Energy Challenge at Izmir, Turkey. Contact: Phone: 216-464-5365, Email: iaee@iaee.org URL: www.iaee.org

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