



# Energy financing for energy retrofit in COVID-19: Recommendations for green bond financing

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## Abstract

The aim of study is to estimate the role of energy financing for energy retrofit in COVID-19, with the intervening role of green bond financing. For this, Kalman technique is applied to infer the empirical findings. It is found that energy financing is significantly dependent on green bonds, and green bonds have a significant role in energy retrofit in E-7 economies specifically. It is further found that E-7 economies gained significant rise in energy efficiency financing green bonds financing, that has supportively extended energy retrofit - before and during COVID-19 crises. It is further found significant that the E-7 nations have to put a lot of money into hydro and nuclear energy for energy retrofit, with low carbon emissions. In the light of COVID-19 crises, this study offers policy recommendations for effective energy management. However, such policy recommendations are expected to finely serve the financial intermediaries and national governments of E-7 economies to better optimize energy financing through green bond financing. The novelty of the study exists in topical framework and research directions, talking about the way forwards for energy efficiency financing - which is one of the latest issue of the recent times. Hence, this research provides some empirical verifications about energy financing in COVID-19 crises for energy retrofit, and shares some suggestions for stakeholders.

**Keywords** Green financing · Energy dependence · Energy transition · Renewable energy · Energy efficiency

## Introduction

Energy efficiency financing in COVID-19 crises is much needed for energy redevelopment to mitigate the crises conditions during structural imposed crises of coronavirus (Iqbal et al. 2021a, b). There is a need and a gap in literature and policy perspective to understand this topicality and respond to the question that how green bonds can better contribute in energy efficiency financing for energy redevelopment, especially under COVID-19 crises period (Li et al. 2021a, b, c). This is the motivation of this inquiry. To keep temperature, rise to 1.5 °C and avoid catastrophic global warming, the International Panel on Climate Change (IPCC) recommended mobilising public funding in their most recent report (Alemzero et al. 2021a, b). Annual green funding of US\$1.5 trillion is necessary until 2030 to fully implement the Paris Accord (Li et al. 2021a, b, c). Up until now, attracting private investment in green energy in Asia has been a major challenge. The 1.5 °C route demands a significant change in investments in order to increase low-carbon investments to the required level (Anh Tu et al. 2021). To make this transformation, government actions must reroute

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funds. Promoting debt securities is one strategy to get more people interested in low-carbon initiatives and hence encourage investment (Ahmad et al. 2021). Environmental bonds should only be used to support reduced initiatives like climate change mitigation or adaptation, natural resources, biodiversity protection, or waste prevention and management, but proceeds from general bonds may be used to finance any lawful initiative (Alemzero et al. 2021a, b).

However, in order to fulfil the region's growing energy demand due to the economic expansion (Iqbal and Bilal 2021), population increase and improved energy access, it is critical to raise green funding. In order to spark green finance in the area, which is now an increasing emphasis of government policies, a significant change in investment patterns is required. Green bond standards, green bond grant programmes and governmental debt securities are all becoming more popular in Asia (Tehreem et al. 2020). As an alternative form of financing for low-carbon developments, bonds are gaining popularity throughout Asia as well as the rest of the world (Tiep et al. 2021).

Since its inception in 2012, the green bond market has expanded from US\$3.4 billion to US\$156 billion (Sun et al. 2020a, b). The European Investment Bank and the World Bank were the first to issue green bonds in 2007 and 2008 to seek private investment for low-carbon projects. E7 countries, after joining the green bond market in 2015, are now the world's largest issuer of green bonds (Xu et al. 2020). In 2016 and 2017, E7 countries issued green bonds totaling US\$34 billion and US\$31 billion, respectively (Sun et al. 2020a, b). Using data from Console (as of July 2019), governments official websites and the literature, this paper reviews issuance of green bonds in three largest green bond issuing countries in Southeast Asia, i.e. Asia, Indonesia and Malaysia, and three government policies which backed them, i.e. green bond structure, relationship grant strategies and supreme debt securities (Baloch et al. 2020).

In Southeast Asia, green bond award programmes did boost the issuing of green bonds, according to the findings. The use of debt securities in these nations to fund cleaner energy projects worldwide did not, however, inevitably lead to decarbonization in these nations (Iqbal et al. 2021c). Analysis of green bond grant schemes has led to policy suggestions for green bond grant design process (Mohsin et al. 2021). In order to ensure that green bond grant scheme supports decarbonization inside the country where the bonds have indeed been issued, legislators need to limit eligibility requirements only to community projects and/or limit re-financing of projects in green bond grant design process (Chandio et al. 2020). About a third of E7 countries' final energy consumption and CO<sub>2</sub> emissions are accounted for by the construction industry. Housing and Urban–Rural Development (MoHURD) estimates that E7 countries' cities already have 60 billion square metres (M2) of floor space and that this number is rising by 2 billion M2 each year. Buildings built before 2010 in E7 countries have a low

energy efficiency financing and do not meet E7 countries' energy efficiency financing requirements in excess of 90%.

In E7 countries' quest for a more provided by the natural and energy efficiency financing and low-carbon route, the building energy retrofit industry plays a critical role. The Chinese government has pushed for more energy efficiency financing construction methods during the last decade (Agyekum et al. 2021). First published in 2005, the GB50189-2005 national building energy efficiency financing design standard has since been updated to include newer technologies. As of 2006, it has published a Green Construction Code. To speed up green construction growth in E7 countries, the government enacted a number of new laws and regulations, as well as policies, rules and professional specifications and recommendations (Iqbal et al. 2021a, b). A total of four kinds of control and regulation instruments are being applied in E7 countries' building energy retrofit policy: economic/market-based instruments, fiscal instruments and information and voluntary activities. when it comes to enforcing mandatory building energy retrofits, E7 countries are now confronted with two key issues (Zhang et al. 2021). It is one thing to say that the present legislation, policies, standards and guidelines are based on training societies and firms' implementations of building design and construction stages (Baloch et al. 2021).

It is estimated that 90% of E7 countries' EPC model in the building energy sector is also the shared savings, making it the targeted model of this study (Xu et al. 2020). ESCO assumes riskiness by using the shared saving concept, which necessitates the use of outside finance. Since 2006, the Chinese government implemented several measures, including substantial subsidies, to enhance building energy efficiency financing in order to adopt and scale up energy efficiency (Li et al. 2021a, b, c). The most important policies are included in two government documents of (1) Speeding up the Implementation of Contract Energy Management to Foster the Growth of Electricity Service Industry and (2) Measures for the Planning of Economic Reward Funds for Contract Energy Management Projects that are published in 2010. State financing has served as a significant incentive for a variety of market participants in these two agreements (Chohan 2021). Public subsidies alone will not be enough to universal sustainable construction and building energy retrofit in E7 countries due to the significant funding gap. In order to close the enormous financial gap needed in order to meet the country's decarbonization goal, it is critical to devise new funding structures to entice private sector investment (Hussain et al. 2021). A business process and performance-oriented instruments for increasing energy retrofitting are supplied by energy service companies (ESCOs) via energy efficiency (Ashfaq and Bashir 2020). Constructing energy-saving initiatives on a large scale is difficult because ESCOs in E7 countries have limited access to finance (Irfan et al. 2021). The large total equity volume and reduced risks associated with EE upgrades make funding

EE projects in the construction industry an appealing investment opportunity for financial institutions (Khokhar et al. 2020). In order to take advantage of these advantages and speed up funding for increasing energy retrofit, financial firms must overcome significant obstacles (Ghaffar et al. 2020).

It is estimated that the majority of ESCOs are classified as MSMEs, or micro- and small-and-medium-sized enterprises, according to the Ministry of Industry and Information Technology of E7 countries (Iqbal et al. 2021a, b; Wang et al. 2020). ESCOs have had a hard time developing their building energy retrofit business and implementing comprehensive energy retrofit solutions due to a lack of readily available finance. It has been found in previous studies that, due to lack of access to green financing, the majority of EPC projects in the construction industry use smart management and monitoring systems and invest new initiatives to help cooling, heating and lighting systems as a result of their nationwide EPC survey (Latif et al. 2021). According to Zhang's research, ESCO would never engage in building energy retrofit because of the high costs and lengthy pay-back periods (Ali et al. 2021). There is evidence to suggest that numerous obstacles, particularly financial ones, have reduced the market for increasing energy retrofits. According to the research, increasing fuel conversion project funding is the biggest barrier to implementation, but other aspects like education and public consciousness were also found to be important (Iqbal et al. 2021c). Energy efficiency financing for investments are seen by banking firms to be difficult and dangerous due to their high transaction fees and a general lack of understanding of financial rewards (Shah et al. 2021).

Property managers, who are often not professionals in building energy efficiency financing, failed to develop energy efficiency financing policies and guidelines to improve their buildings' energy performance. Furthermore, E7 countries' financial regulatory structure is immature due to weak implementation, incomplete knowledge and a lack of experience with the global banking markets. Both problems need finding ways to improve E7 countries' buildings fuel energy efficiency financing, which has boosted energy demands retrofits in the construction industry. According to estimates, different energy conservation technologies might help save anywhere from 30 to 50% of the existing building power consumption. E7 countries prefer the achievement business strategy of energy performance contracting (EPC) for structural energy efficiency financing improvement. When it comes to EPCs, an energy services provider (ESCO) defines it as a contract with a building owner or user for the provision of an energy performance service, in which the firm has considerable risk and manageable tasks and compensation is tied to success.

In this paper, the first section presents in study introduction, the second discusses the review of past studies, the third portion explains the methods and research design, the fourth portion discussed and interpreted findings and the

last section concluded with different implications of the research.

## Literature review

The Reform Commission and other government agencies produced Guidelines for Developing a Green Banking Industry in 2016 (Shah et al. 2021). One of the policy's objectives is to assist in improving the environment, responding to climate change and conserving and energy efficiency financing using resources, such as financial services provided to projects that support investment and financing in environmental protection, energy efficiency financing, renewable technology, green transportation or eco-friendly architectural design (Shakouri et al. 2020). A significant conclusion of this research is the definition of green finance in building energy retrofit as institutional arrangements that support building improvement via the use of credit derivatives such as eco-loans and similar goods (Taghizadeh-Hesary et al. 2021).

The essential challenge in the framework of E7 countries' building energy retrofitting will be how to properly identify and then create and implement customised rules at the collective level and various business models at the practical micro-level (Yoshino et al. 2020). The purpose of this study is to ascertain the most significant barriers to green finance for ESCOs and financial firms on both the supply side, using a literature search, in-person interviews and a state-wide survey (Ward, 2012). A profile of Chinese ESCOs in terms of green finance availability is developed using survey data, along with recommendations for overcoming barriers (Ko 2020). When the results of this research are communicated with relevant stakeholders, they may aid in their understanding of the present situation of E7 countries' sustainable building retrofit finance industry (Xing and Fuest, 2018).

Energy and renewable energy projects in ASEAN have encountered a variety of barriers, restricting their scope and speed. Developers will continue to face financial, macroeconomic and regulatory challenges. Local financing markets that are insufficiently developed and a low rate of return on investment are two examples of financial impediments to renewable power generation. Inadequate private equity capital is a significant concern, and underdeveloped local financial markets may act as an obstacle. As a consequence, when leveraged buyout financing is unavailable, projects face significant resource constraints.

Unknown regulatory and legal framework, notably low feed-in tariffs and unbendable public–private partnership agreements, are significant impediments to the development of renewable projects (Winner 2012). Contract standardisation is a challenge in numerous ASEAN countries, since public–private partnerships are negotiated and approved on an individual level, resulting in information scarcity (Egenhofer

et al. 2020a, b). As a consequence, this practise violates global standards. Weak financial markets, political and commercial risk and other macroeconomic issues all have an energy efficiency financing on renewables financing, but they are particularly prevalent in lower Mekong states such as Cambodia and Lao PDR. Bank loans now provide for the vast bulk of financing for energy efficiency financing, and this money has proven woefully inadequate. Alternative types of energy efficiency financing include Energy Performance Contracts (EPCs), in which ESCOs use project revenues to repay loans, and green banks (Collins 2014), which invest a combination of public and private resources in fuel energy efficiency financing (Macchiaroli et al. 2021). Ecologically responsible operations and companies have enormous potential, and green bonds, a mutual fund intended particularly to fund them, also hold considerable promise: the value of green bonds for energy efficiency financing increased from 16 to 47 billion dollars in 2016 (Baca et al. 2017).

Inadequate liquidity or a lack of awareness on the part of consumers and lenders may act as impediments to energy-saving measures. Market impediments, such as liquidity constraints, obstruct the implementation of energy efficiency financing projects (Blumstein and Stevens 1980). Liquidity may be constrained as a result of the rigorous collateral requirements and the small size of energy-saving projects. Banks, for the most part, have tight internal credit requirements that require the provision of traditional collateral such as real estate or other physical assets as security for loan operations. Generally, banks will not take security for energy efficiency financing. This is a major impediment to ASEAN's attempts to support energy efficiency financing programmes. Lenders frequently require security for initiatives in the range of 80 to 120% of the quoted amount, depending on the perceived risk. This is a required standard. According to this view, fuel energy efficiency financing technology obtained with borrowed cash may be considered security. This finding, however, falls short of the required 80–120% construction volume due to the omission of fuel energy efficiency financing.

Energy efficiency financing initiatives are often scattered and small in scope (Taylor et al. 2008), and financial institutions such as banks see this as a significant barrier to securing more finance. Even though energy efficiency financing initiatives are often less expensive, they provide greater yields and repay for themselves more quickly than infrastructure improvements (Geisinger 2015). On the other side, the small loan amounts have a detrimental energy efficiency financing on lending choices (Egenhofer et al. 2020a, b). As a result, corporate energy efficiency financing loans are less in size. Due to a lack of financing, some equipment purchasers may choose for a less power model, resulting in less money spent on energy efficiency financing (Rezessy and Bertoldi 2010). A funding institution may overlook a small project, even if the total return is high. These small

energy efficiency financing often go underfunded and finalised unless they can be merged into a bigger project to save transaction fees (Gergey et al. 2002).

Green bonds enable debtors to improve their image, assert their sustainability and attract ethical investors without resorting to other financial instruments (Patterson 1996). The Green Bond Principles describe a green bond as a 'debt security issued to generate cash exclusively for climate change or environmental initiatives'. Green bonds were originally issued by multilateral development banks in 2007, and the private sector started to use them more often in 2014. In 2015, over 20 signatories pledged to boost their green bond investments, totalling \$11.2 trillion (Zhang et al. 2021). Green bonds offer lower interest rates and less restrictive covenants than bank loans, making them an appealing source of capital for businesses wishing to support energy efficiency financing programmes (Nawaz et al. 2021). Green bond growth is projected to continue to be strong for the foreseeable future, given their strong performance so far (Zhou et al. 2020). According to Wu et al, (2020) research, green bonds outperformed the market in terms of spread narrowing in the first 28 fiscal days following issuance, indicating a favourable credit profile. When it concerns to yield, many research found no difference between green and conventional bonds, while others found a little advantage for green bonds. This price, however, may be significantly reduced by accreditation.

Global demand for green bonds is increasing, but the green bond markets in Singapore, the Philippines, Malaysia and Thailand total barely \$549 million. Obtaining sufficient market may be challenging owing to Southeast Asia's national green bond markets' small size. Large investors are unable to engage in this area's green debt markets due to the requisite minimum bond value of around US\$230 million for investment firms. Indonesia has issued a \$1.25 billion green sukuk to address this problem. States may use privatisation to convert green loans into higher-value assets, taking cues from advances in the green asset-backed securities markets in the United States, Canada, Australia and the European Union (Hafner et al. 2020). The low credit scores of government bonds may contribute to the lack of demand in South Asian green bond markets for covered green bonds guaranteed by their issuers (Falcone 2020). Because governments are the primary issuers of green bonds, demand is primarily controlled by their nations' creditworthiness. This may result in a chronically gloomy outlook for green bonds in these countries (Cui et al. 2020).

On the other hand, growth in international green bond markets may have beneficial externalities for Southeast Asian economies. It is possible that awareness of the hazards associated with green bonds may expand around the world, eventually reaching Southeast Asia. E7 countries Railway Corporation is the world's largest issuer of green bonds. Due to E7 countries' large investment in Southeast Asia and its proximity to the region, the expansion of the Chinese green

bond market may benefit demand for green bonds in Southeast Asia. E7 countries have a sizable investment portfolio in Southeast Asia. According to the ICMA’s Green Bond Principles, green bond proceeds may be used to promote environmental sustainability programmes such as renewable energy, pollution prevention/control, clean transportation, climate change adaptation and green buildings.

## Methodology

### Study data

Energy2 redevelopment may be measured by looking at measures such as green bonds, and energy efficiency finance in COVID-19 crises. Data on the E7 nations is compiled from a variety of sources. There are 110 listed renewable energy businesses active in E7 nations, with 61 being wind energy companies, 13 being geothermal companies, 121 being renewable energy producers and 77 being solar power firms. For empirical estimate, the researchers prepared a data sheet with information on bank loans, predicted income, economy size, energy efficiency investments and government subsidies. The data for E7 nations came from a variety of sources, including the World Bank database and the OECD database, and covered the time period from October 2019 to October 2021 (monthly data) during which the COVID-19 epidemic occurred.

### Empirical measurement and estimation

The Malmquist index is what we use to track energy efficiency improvements. It is possible to use the Malmquist index to

measure the adequacy of input–output connection when there is multidimensional source distortion. The issue may be explained as follows if we use the scaling factor requirements:

$$IC = \sum_j C_{i\text{verr}} (\text{Loss}_j + G_i) = \sum_j C_{\text{min}} \left( \frac{\omega_j^*}{V^2} + G_j \right), j \quad (1)$$

$$HC = \sum_j C_h (G_j - E[D_j]), j = \{p, o\} \quad (2)$$

$$SC = \sum_j C_x (E[D_j] - G_j), j = \{p, o\} \quad (3)$$

$$U^{\text{mat}} = \text{hln} \left( \sum_j \left( \frac{L}{P_j} - G_j^{\text{min}} + \theta \right) \right), j = \{p, o\} \quad (4)$$

Using moment parameters using dynamic prediction is possible even when the variables are unpredictable. There are several elements that have an impact on renewable energy, and it is difficult to account for each one. In the past, research has shown that adding more factors makes it more difficult to portray their complex interactions.

$$\begin{aligned} \prod (P_j, G_j, L) &= TR - IC - HC - SC - IP \\ &= \sum_j P_j^* E[D_j] - \sum_j C_{im=x} (LL_j + G_j) - \sum_j C_b (G_j - E[D_j])^+ \\ &\quad - \sum_j C_x (E[D_j] - G_j)^+ + \lambda (U^{\text{mit}} - I_e gL) - r(1 - \lambda)L \end{aligned} \quad (5)$$

It is essential for researchers to make a choice in order to discover in which the elements have likewise a most important.

$$G_{ji}^* = \text{Root} \left[ 15\sqrt{2}\gamma C_h (M_j^{\text{mam}})^4 P_j V^2 + \dots + (3\sqrt{2}C_h V^2 + 3\sqrt{2}C_x V^2 - 3\sqrt{2}P_j V^2) \#1^5, i \right] \quad (6)$$

$j = \{p, o\}, i = [1, 5]$

$$Y_t = \alpha_0 + \alpha_1 X_t + \alpha_2 Z_t + u_t \quad (7)$$

Equations (6) explains the nonstationary procedure, for the constructs of recent study to estimate, with the provision - if all elements of matrix are equal to one. So the Eq. (6), is as given as above and is supporting to draw the equation (7).

$$ME : Y_t = \beta + \beta_1 X_t + \beta_2 Z_t + u_t TE : \beta_{it} = \emptyset_i \beta_{it-1} + v_{it} \quad (8)$$

$$ME : Y_t = \beta + \beta_1 X_t + \beta_2 Z_t + u_t TE : \beta_{2t} = \emptyset \beta_{2t-1} + v_t \quad (9)$$

To ensure that the variables are stable, use the Copenhagen test. OLS analysis, which differs from the Extended Kalman model in these equations, is used by many estimate approaches. Through these equations depicts the OLS concept.

$$WPE_t = \beta + \beta_1 CPI_t + \beta_2 EP + \beta_3 EE + \beta_4 EFF_t + \beta_5 HJI_t + u_t \quad (10)$$

This research went and face-to-face interviewed 21 ESCOs, 12 local banks and 17 local property agencies on-site to discover the energy efficiency financing approaches taken by ESCOs and financial firms for this investigation.



**Table 1** Descriptive statistics of energy redevelopment indicators

Indicators	Mean	SD	Skewness	Variance
Energy storage system	-0.00111	0.002643	0.009326	0.007341
Energy frequency sensitivity mode	0.000461	0.000518	-0.01203	-0.00242
Energy supply fault ride through	-0.00053	0.006871	-0.00869	-0.00046
Fixed speed induction	0.001554	0.000325	0.007323	0.009575
High voltage ride through	0.002429	0.003045	-0.00701	-0.00257
Fully converted wind generator supply	-0.00969	0.001737	-0.0021	0.002627
Internet of things	-0.0054	-0.00141	-0.00563	0.002266
Photovoltaic	-0.00352	-0.00418	-0.00397	-0.01935
Low voltage through in thermal plants	0.002684	-0.00087	0.010965	0.002643
Point of common coupling	0.005824	-0.00174	-0.01254	0.006516
Rate of change of frequency	-0.00058	0.001065	-0.00088	0.002241
Transmission system score	-0.0049	-0.00835	0.003816	-0.00298
Router rated speed	-0.00091	-0.00344	-0.00272	0.002967
Nominal wind energy power	0.002233	-0.00499	-0.00822	0.006324
Real wind energy power	0.005306	-0.01139	-0.01178	-0.00251
Power system base	0.004392	-0.0007	-0.00328	-0.01374
Power generation kilowatts	-0.00145	-0.00103	0.012416	0.009458
Power generation Megawatts	-0.00736	-0.00293	-0.00568	-0.00769
Power generation in millisecond	0.002476	-0.00324	0.003119	-0.02284

## Results and Discussion

### Empirical findings

According to this study's findings, visits and interviews are needed to share those findings with key stakeholders and to get insight into the steps taken by relevant actors and best practises being followed to overcome the major hurdles discussed in this section (see Table 1). The short or unpredictable lifespan of local authority funding schemes was found to be a major impediment at the policy level in this research.

To make matters worse, several of them are heavily reliant on government funding. However, local housing authorities have made it clear because energy-saving regulations have the benefit of not imposing a strain on the national or regional budget and are therefore independent of budgetary changes. They, on the other hand, are politically unsustainable unless they have backing. After speaking to both ESCOs and banks, it is clear that public financing is critical at this time and should be maintained until the building EE retrofit market has matured completely. Almost of participants believe that public money should be available for some time another 5 years when asked in this survey by ESCOs and local banks about it. Divided incentives, often known as the Head of school dilemma, are a significant roadblock at the government level. Local property agencies now get central federal subsidies (see Table 2). Subsidies go to housing developers when they are combined with municipal matching contributions. As shareholders, ESCOs will be unable

to reap the rewards of increased energy efficiency financing in this situation.

To encourage ESCOs to make EE improvements to buildings, the primary goal of public funding is to reward them. Subsidies, on the other hand, do not always go to ESCOs but rather to housing developers. In addition, only ESCOs registered with E7 countries' National Development and Reform Commission (NDRC) are eligible for public subsidies. ESCOs must be a particular size to be eligible for registration, and most micro-sized ESCOs are not. As a result, they are eligible for government assistance. This obstacle may be overcome by a building EE achievement subsidy system in which all ESCOs are eligible and receive a direct subsidy based on the performance of the building's EE. This payment is computed on this basis. That way, financial incentives will only go to those who can really act on them. A relatively low power price is a major policy obstacle, whereas a rise in the value of fuel is a more complicated matter. For Chinese residents, power generation and delivery are heavily subsidised, resulting in lower energy prices that limit energy efficiency financing to save energy and enhance EE.

According to this study's conversations with housing associations, E7 countries' national governments are prepared to incorporate the construction industry in the country's Emission Trading System instead of raising energy prices (ETS). Start with the energy efficiency financing National Standard for Building Carbon Emission Calculation released by the Ministry of Local Government And housing & Rural Development. The building industry will be ready to participate in the national ETS after a number of years of

**Table 2** Kalman measure indicators

Indicators	Coefficient	SE	Z-score	Prob
β1	0.7268	0.1719	0.0217	0.0175
B2	0.0415	0.4123	0.0732	0.1305
B3	0.0134	0.1144	0.0017	0.4033
β4	0.0109	0.0178	0.0605	0.3256
β5	0.0055	0.0776	0.0124	0.3271
B5	0.1774	0.6055	0.2705	0.0125
β7	0.2403	0.0562	0.0764	0.0025
β8	0.7383	0.2642	0.0441	0.0311
β9	0.1278	0.1035	0.4617	0.0545
β10	0.0809	0.1262	0.1689	0.0099
β11	0.0742	0.1614	0.0642	0.0507
β12	0.0585	0.0152	0.0775	0.0018
β13	0.2887	0.2434	0.3615	0.0116
β14	0.3117	0.1903	0.1006	0.1038
β15	0.2119	0.0763	0.0657	0.2121
β16	0.1141	0.0235	0.8769	0.2278
β17	0.0882	0.5864	0.0811	0.3147
β18	0.4448	0.1371	0.0044	0.0141
β19	0.0212	0.9322	0.0381	0.1348

registering construction carbon dioxide emissions in accordance with this criterion. There is little doubt that ETS is a key driving factor in E7 countries’ construction industry to scale out EPC and encourage EE development as well as the use of sustainable or clean energy, according to Zhang et al. Solutions and best practises are gathered, evaluated and discovered by visiting ESCOs, local banks and local housing authorities, in particular, by visiting relevant industry standards on releasing green funding for EE retrofit.

ASEAN’s green capital market is still in its infancy, and it confronts some formidable obstacles. These issues confront both green bond issuers and buyers. Limited credit absorption capacity and the expense of satisfying green bond standards have been identified as two significant issues for issuers in the literature. Investing in green bonds is difficult because of the lack of available indexes, listings and ratings, as well as the absence of data and analytical abilities. As a result of their modest size and restricted capacity to absorb loans, local firms do not have access to the climate bonds

**Table 3** Estimates of Hansen parameter

	Stochastic trends	LC statistics	Deterministic trends	Significance
COVID-19 lockdown	0.220	0.286	0.222	0.000
Energy redevelopment	0.300	0.643	0.740	0.000
Energy efficiency financing	0.609	0.600	0.698	0.000
Green bonds	0.772	0.823	0.976	0.000

issuance procedure. As a result, green bonds are a tool for larger companies to raise money.

This becomes a roadblock to further growth of the bonds market. Green bonds can be a viable market in larger markets like E7 countries, thanks to the sheer volume of large entities looking to fund their environmental projects with green money (see Table 3). However, countries like Singapore, which lack suitable projects to use green bonds for, face a major challenge in making green bonds available to everyone. Assuring that the status of “green bonds” is verified and monitoring how bond revenues are used by issuer is the responsibility of fourth insurance companies such as specialist research organisations. Potential customers, on the other hand, have no idea how to finish the third-party review procedure. Small borrowers are additionally hampered by the hefty expense of getting a third-party opinion, which may vary from USD 10 to 100 k. External review expenses do not go away just because Singapore and Malaysia have created grants to compensate them. There have also been concerns raised by issuers regarding the significant expenses associated with disclosure.

The lack of economically viable green capital investments is a significant obstacle for issuing green bonds to buyers in ASEAN. Currently, only 45% of renewable energy projects in Southeast Asia can be financed without the help of the public sector, according to industry professionals. Unless the public sector provides non-commercial funding, Marsh and McLennan predict that 60% of all infrastructure projects in Asian developing nations are not ‘bankable’. In countries where green investments are scarce, assembling a portfolio of economically viable green assets is difficult. Economic exposure might increase the cost of the investment since the assets are spread across many nations. It is also challenging for financial decision-makers to evaluate project risk and

**Table 4** Energy redevelopment verification

Study constructs	HVRT		Power factor	
	V max	T max	Leading	Lagging
COVID-19 lockdown	0.332	0.337	0.313	0.351
Energy redevelopment	0.495	0.838	0.601	0.078
Energy efficiency financing	0.101	0.900	0.808	0.321
Green bonds	0.777	0.711	0.889	0.003

seek green funding since corporations are not disclosing similar information (see Table 4). Environmental factors' financial ramifications are just now beginning to be appreciated. The good investment industry and creditworthiness are poorly understood in a network of banks. This makes risk management difficult and may result in funds being misallocated to high-risk endeavours.

As a result, less green money would be available. Exchange-implemented green bond listing criteria may point bond investors in the direction of securities that match their investment objectives. Green bond issuers would save money on financing as a consequence of an increase in the amount of money flowing in. Investors may also profit from green bond indexes in the same way by matching their preferences to particular green assets. To assist the market better match green bonds with worldwide norms, rating agencies use environmental information to improve their green bond evaluations. Yet only a tiny number of green goods and policies are promoted via green bond indexes, listings and ratings.

Increasing the amount of the economy is the same as increasing the quality, and this is what is meant by productivity expansion. Because of the new normal, E7 countries' economic growth is increasingly based on energy efficiency financing growth, and the state's financial development is mainly driven by the innovation concept of quality first and energy efficiency financing foremost. Improving energy efficiency financing is crucial to help E7 countries' economy expand at a high standard. For some time now, the Chinese government has been actively promoting quality economic development as a means of nation building. As a result, for a high-quality economic system to exist, a secure and stable electricity supply is required. Saving energy thus has significant practical implications for economic growth of advanced quality.

Natural fuel usage defines E7 countries' large energy consumption structure and backward energy technologies, both of which are based in the country's poor energy efficiency financing. As a result of poor energy use, E7 countries' long-term growth is stymied. Low energy financing efficiency also makes it difficult to modernise an industrial structure. Coal, steel and chemical industries all have substantial amounts of obsolete and unnecessary manufacturing capability. When it comes to E7 countries' future, the country

must balance environmental conservation with economic development. Low energy efficiency financing efficiency also wastes a big amount of resources, as we have seen. Several elevated nations have begun to decouple their energy consumption from economic growth as a result of global growth and technical advancement.

### Sensitivity analysis

Despite the central government's policy incentives, E7 countries' energy efficiency financing efficiency remains well behind that of wealthy nations. The connection between energy efficiency financing efficiency and economic development quality, thus, must be discussed. This is why an academic's attention has always been drawn to how closely energy and economic growth are linked. How much does energy use contribute to economic development, as we know it from the research available? Researchers cannot agree on anything since they are all doing their own research. According to one popular theory, energy is a necessary input for economic expansion to occur.

A growing number of economists are looking beyond the standard model of macroeconomic growth to include energy considerations into production functions in order to better understand where economic growth comes from. Previously, Dong et al. (2021) analysed provincial data from E7 countries to find that a 1% increase in energy consumption increases GDP by 0.05%, but the energy efficiency financing of various sources of energy on economic development was varied. Researchers Hao et al. (2020) found via the use of a VAR model that energy intake was detrimental to economic development. Similar results have been seen in international statistics as well (see Table 5).

With the increased reliance on conventional energy sources like coal and oil, it is becoming more difficult to sustain economic growth without causing environmental degradation and ecological harm. The share of renewable energy in the energy consumption system is steadily growing as the benefits of renewable energy become more clear. The use of renewable energy, according to several researchers, has the potential to considerably boost the economy. Few academics have shown as well that energy efficiency financing promotes economic development while lowering greenhouse gas emissions.

**Table 5** Multiple uncertainty levels — robustness test

	Example 1 $\gamma=5000$ , High	Example 2 $\gamma=5000$ , Low	Example 3 $\gamma=0$ , High	Example 4 $\gamma=0$ , Low
COVID-19 lockdown	0.673	0.893	0.776	0.091
Energy redevelopment	0.786	0.456	0.001	0.452
Energy efficiency financing	0.441	0.784	0.087	0.671
Green bonds	0.592	0.777	0.093	0.993



## Discussion

For economic growth to be of top quality, it is essential to build a green and energy efficient finance power process and enhance energy efficiency financing. Energy consumption and economic growth have been studied in the past, but they failed to take into account the influence of energy efficiency finance on energy rehabilitation in previous research. An effort is made in this research to address the issue of whether finance for fuel efficiency can be a significant driver of quality economic growth in E7 countries using province data. The facts of the matter have come to light for us. Energy-saving finance makes intuitive sense since it may help E7 countries' energy efficiency drastically improve, but there is no concrete data to back this up. In E7 countries, we have yet to see the good effects of efficiency finance, but we cannot ignore the role that efficiency financing plays in economic progress.

Therefore, E7 countries' energy efficiency financing may be low enough to enable quality economic growth, and it most likely reflects the presence of a non-linear energy efficiency financing system in E7 countries. As a result, we discover that energy efficiency finance and energy rehabilitation have a clear U-shaped association (Conci and Schneider 2017). An in-depth investigation reveals a significant regional gap in finance for energy efficiency and energy rehabilitation. Energy efficiency financing has a greater impact on energy redevelopment in the eastern region than in the central or western regions, so the effect of energy efficiency financing on revitalisation differs by area. Finance for energy efficiency increases energy redevelopment in the eastern areas, while it diminishes it in the centre and western states. Energy efficiency financing. As a result, the economic system has a significant impact on the relationship between the funding of energy efficiency projects and the rehabilitation of power generation.

Advances in energy efficiency have been studied from two separate angles in the past. Some study has attempted at the return on investment from an energy-saving standpoint, while others have examined the venture's overall profitability. The emphasis here is on the perceived threat of diverging from energy-saving goals. So the risk perception related to energy efficiency rises in tandem with the amount of funding and the quantity of energy saved, and their variance rises accordingly. Instead of a dangerous expenditure, research show that energy efficiency might reduce the perceived risk for decision-makers. Energy efficiency may be compared to insurance in that it lowers future electricity costs and, as a result, the variability of those prices.

No one has ever described how these two viewpoints vary and how sensible decision is influenced by them. Our research is based on EUT and uses a simple and accessible mathematical model with a CARA utility function to show the distinction between the different views and their

combination. Based on averaged data from Germany office properties, we test our theoretical insights using a Simulation to forecast the distribution of energy bill expenditures and savings following an ecological retrofitting of a commercial space. Because business decision-makers behave more logically than company decision, we picked a corporate situation for my study case.

## Conclusion and policy implications

Our theoretical and empirical studies illustrate how the two viewpoints impact investment decisions for energy efficiency in a different way. Decision-makers spend a lot more in energy efficiency from the standpoint of the energy bill since it reduces their perceived risk. As a result, their projected return on investment rises as the investment amount climbs. When looking at energy efficiency from the standpoint of return on investment, on the other hand, the ideal investment level is substantially smaller. Anyone who uses both viewpoints while making a choice will have an investment amount that falls between the two perspectives' peaks. We have discovered two important things about energy policy as a result of our research. When it comes to rational decision-making, putting the investment and energy bill perspective in place opens the door to more sustainable investment behaviour since it emphasises the need of energy efficiency and helps persuade stakeholders that doing so lowers their future energy costs. The idea that looking at the energy bill encourages investment must, of course, be tested in the actual world. However, we believe that the theoretical considerations presented in this research have the potential to enhance future energy efficiency awareness campaigns by emphasising the financial benefits of energy efficiency and drawing attention to the possibilities for risk reduction. In order to provide more effective incentives for long-term investments, current subsidy programmes and communication campaigns may go into greater detail about risk reduction. Second, our research adds to the existing body of knowledge on the effect of risk perception on energy efficiency investment choices. It is critical to understand how decision-makers see energy efficiency from many angles while evaluating, developing and implementing policy instruments. If a decision-maker perceives carbon taxes or subsidies as risky, then they are more effective than other mechanisms. To improve the projected financial return on energy efficiency investments, these two tools have been developed to work together.

1. Government agencies should place a high priority on developing a long-term system for generating and using energy. While increasing its contribution to energy technological advances and the conservation sector is important, the federal government should also stimulate

creation of new energy industries. Traditional energy sources, as well as new energy sources, should be included in an efficient energy supply system in order to encourage continual improvement in the energy supply structure. While this is going on, energy usage should be adjusted and EFF improved on a continuous basis. Because E7 countries' economic development has shifted, local governments should pay greater attention to the quality of economic growth and incorporate high-quality content such as energy efficiency and industrial upgrading in the assessment criteria.

2. Local governments should devise development plans and implement fiscal, tax and financial policies aimed at boosting EFF in order to keep the economic development pattern moving forward at a faster pace.
3. When creating policies and development plans, E7 countries should thoroughly consider regional peculiarities and realities. The eastern and central areas should serve as role models for developed regions by fostering cross-regional interaction and collaboration. Using regional integration initiatives to help the eastern and central areas increase their EFF and QUAL. For economic growth to be successful, the western area must establish strong institutions and improve infrastructure building, as well as provide attractive incentives to the private sector.

These are the paper's limitations. Preliminary studies can only be carried out at the provincial level due to a lack of data on urban energy use. Additional research into the link between energy efficiency and quality is needed to better understand these two concepts. To do so, more theoretical processes and influencing elements are needed to better understand the relationship between EFF and QUAL. In addition, it is critical to look at how energy efficiency affects industrial development quality. The future study focus will be on how to create an index system to measure how well a product is being developed.

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**Data availability** The data that support the findings of this study are openly available on request.

## Declarations

**Ethics approval and consent to participate** We declare that we have no human participants, human data or human issues.

**Consent for publication** We do not have any individual person's data in any form.

**Competing interests** The authors declare no competing interests.

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