ENERGY CONSUMPTION, ECONOMIC GROWTH AND DEVELOPMENT FINANCE: EVIDENCE FROM THE MIDDLE-INCOME COUNTRIES AND INNOVATIVE SOLUTIONS FOR EFFECTIVE ENERGY MANAGEMENT IN SMART CITIES

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Although energy consumption is highly related to economic growth and development finance, a consensus on the direction of causality among them has not been reached. To this end, this study aims to investigate the causal effect of economic growth and development finance on energy consumption with a focus on middle-income countries over the period of 1994-2014. Our empirical highlights unidirectional causality running from economic growth to total energy consumption; unidirectional causality running from financial development to total energy consumption; unidirectional causality running from renewable energy consumption to financial development; and unidirectional causality running from non-renewable energy consumption to economic growth. Based on the empirical findings, the article proposes some innovative solutions for effective energy management in smart cities towards sustainable development, harmonizing economic development and energy consumption.

KEYWORDS

Energy consumption, economic growth, development finance, long-term relationship, causality

1 INTRODUCTION

It is widely acknowledged that the energy-growth nexus (EGN) highlights a relationship between economic growth and energy consumption. In detail, the EGN provides an evidence on Granger causality between the 2 variables of interest. They are: (1) the neutrality hypothesis; (2) unidirectional causality from energy consumption to economic growth; (3) unidirectional causality from economic growth to energy consumption; and (4) bidirectional causality. Besides, there has been a growing debate regarding the impact of financial development on energy consumption. As a result, financial development is associated with energy consumption through three channels. They are: (1) the direct effect; (2) the business effect; and (3) the wealth effect. In summary, these effects claim that a higher level of financial development may lead to a rise in energy use. Understanding energy consumption is important as it is one of the sources of environmental degradation. This helps policymakers to suggest feasible policies to deal with real-world problems.

Since the EGN together with the impact of development finance on energy consumption reached a consensus among scholars, there have been growing empirical findings. To the best of our knowledge, these papers focused on estimating rather than investing direction of influence, which leaves room for our contribution. On the other views, we observed that there have been a number of studies aimed to investigate causality effects between growth and/or financial development and energy use. However, these papers are constrained by some limitations.

The middle-income countries represent an interesting setting to study the causality effect of growth and development finance on energy consumption for many reasons. *First*, according to the country classification by income developed by the World Bank, as of 2012, middle-income countries involve 105 countries, accounting for around two-thirds of all countries. The contribution of middle-income countries to the global economic activities is significant. It is no doubt that middle-income countries involve rapidly growing economies, which are key players in international trade and finance. In addition, middle-income countries are contributors to global manufacturing and supply chains, which are considered as the backbone of global activities. *Second*, we are aware that the level of energy consumption of middle-income countries has been increasing over the last decades. For instance, the statistics of the World Bank shows that energy use of middle-income countries increased significantly from around 875 kilograms of oil equivalent per capita in 1994 to nearly 1400 in 2014, which is equivalent to an increase of 57%. From 1994 to 2014, the world only witnessed a rise around 16% in energy use. *Third*, the increase of energy use in this region can be partly attributed to significant growth as well as the development of financial sectors (Ulusoy & Demiralay, 2017; Anton & Nucu, 2020; Chen et al, 2020). Since these studies focus on OECD, non-OECD and EU countries, it follows that the investigation, with a focus on middle-income countries, should have been conducted.

This paper contributes to the relevant literature in three-fold. First, we use various advanced econometrics methods to detect some issues of time-series panel data, such as cross-section dependence, non-stationary, which may cause a long-run relationship. Besides, based on these findings, we apply the Granger causality test, developed by Dumitrescu & Hurlin (2012), to find a direction of influence among the variables of interest. It is widely agreed that the method outweighs other causality tests (Dumitrescu & Hurlin, 2012). Second, we fill the research gap by disaggregating total energy consumption by renewable energy consumption and non-renewable energy consumption as highlighted by Aslan and Topcu (2018). Third, based on the empirical findings, we propose various feasible policies with a focus on middle-income countries to deal with real-world problems occurring in the region.

2 LITERATURE REVIEW

2.1 Energy consumption and economic growth

The relationship between energy consumption and economic growth is intensively investigated. It is widely agreed that the energy-growth nexus can be classified by causality. In particular, there are 4 outcomes (1) the neutral hypothesis (2) the growth hypothesis (3) the conversation hypothesis and (4) the feedback hypothesis.

Based on the above outcomes, there is a bunch of empirical studies, focusing on analyzing the nexus between energy consumption and economic growth, uses different econometrics techniques and time periods. The first study on energy-growth linkage can be traced back to Kraft and Kraft (1978) in which the unidirectional causality running from GNP to energy in the US from the period of 1947-1974. After the seminar work of Kraft and Kraft (1978), many empirical studies have been motivated. Rahman et al (2020) carried out a research on the linkage energy production-energy consumption-economic growth, using a time-series data for China over the period of 1981-2016 and Hatemi-J cointegration and structural-break test. Their results revealed the consumption and production of coal, oil and natural gas cointegrated. Moreover, the authors argued that the use of fossil fuel (coal, oil and natural gas) contributed to economic growth. Topcu et al (2020) used panel vector autoregressive (PVAR) approach to investigate the linkage between economic outcome, energy consumption, natural resources and gross capital formation in 124 countries over 1980-2018. The authors found energy consumption was a source of economic growth for high-, middle- and low-income countries while the contribution of capital, urbanization and natural resources to growth was mixed. Besides, the empirical results highlighted that there was a unidirectional causality running from capital and energy use to growth across three groups of income. Mensah et al (2019) analyzed a relationship among fossil fuel energy consumption, economic growth, CO2 emission and energy price for a panel data of 22 African countries, spanning from 1990 to 2015. The authors argued that their macro panel data involved heterogeneity and cross-section dependence while the variables of interest were cointegrated. Besides, using the PMG-ARDL estimator, they found bidirectional causality exist between energy consumption and economic growth in both short- and long-term in 22 African countries. Using GMM estimator, Kahouli (2019) conducted a study for a panel data of 34 OECD countries from 1990-2015. The primary purpose of their study is to examine both static and dynamic relationship between economic growth and energy consumption. Empirical results of the GMM estimator provided evidence on positively impact of energy use on economic growth in both static and dynamic model and the picture was the same in which energy consumption was dependent variable and economic growth was independent variable. Besides, causality test results showed there was a bidirectional causality between energy consumption and economic growth. Their empirical results were consistent with the work of Dedeoglu (2013); Saboori et al (2014). Khan et al (2019) carried out a research on energy consumption, environmental degradation, growth and financial development, using a panel data of 193 countries over the period of 1990-2017 and seeming unrelated regression (SUR) together with three stage least square (3SLS). Their results revealed economic growth significantly and positively affected an increase of energy use.

2.2 Energy consumption and development finance

The development of financial sector results in various positive outcomes, for example, a reduction in financial risk and cost of borrowing; a greater access to the latest energy efficiency products as well as cutting edge technology due to the emergence of cheaper sources of capital; and among others (Rao, 2003). These changes, in their turn, partly require a higher demand for energy. Various studies have documented three channels explaining the effect of financial development that has on energy consumption (Sadorsky, 2011). They are (1) the direct effect; (2) the business effect; and (3) the wealth effect. The direct effect shows that a lower cost of borrowing encourages individuals to buy consumer durable items (refrigerator, air conditioner, washing machine), which require electricity for operation. The business effect implies that as a result of the availability of various sources of capital, firms gain more incentive to expand existing business. The wealth effect points out that the growth of equity market and/or debt market are highly related to consumer confidence, which is often considered as a source of economic growth.

Many efforts have been made to analyze the relationship between financial development and energy consumption. Anton et al (2020) carried out a research on the influence of financial development on renewable energy consumption, using a panel data of 28 EU countries over the period of 1009-2015 and fixed effect model. Their results revealed a positive impact of financial development, which was proxied by various indexes of banking sector, capital market and bond market, on energy consumption. Using fixed- and random- effect model together with GMM estimator, Ulusoy and Demiralay (2017) conduct a study for a panel data of 22 OECD countries from 1960-2011. The primary purpose of their study is to examine the effect of the development of stock market on oil and electricity consumption. Empirical results provided evidence on the rise of energy consumption could be attributed to expanded stock market. And the authors highlighted that the results were true for both short- and long-run.

2.3 Renewable energy consumption, economic growth and development finance

With the emergence of energy transition, renewable energy consumption has been taken into consideration. In this context, Eren et al (2019) analyzed a linkage between financial development-economic growth-renewable energy consumption in the case of India, spanning from 1971 to 2015. Their empirical results revealed a long-run relationship between financial development, growth and renewable energy consumption and a bidirectional causality between renewable energy consumption and growth. Besides, using the DOLS estimator, the authors argued that both financial development and growth were positively associated with renewable energy consumption. Using FMOLS and DOLS estimators, Sadorsky (2009) conducted a study for a panel data of 18 emerging countries from 1994-2003. The primary purpose of their study is to analyze the impact of income per capita on renewable energy consumption. Empirical results provided evidence on a positive and significant effect of per capita income on per capita renewable energy consumption. In particular, it is argued that an increase of 1% in per capita income is related to an increase between 3.39% and 3.45% in per capita energy use. Padhan et al (2020) used method of moments quantile regression (MM-QR) to investigate the determinants of renewable energy consumption in 30 OECD countries for the period of 1970-2015. The authors found not only oil price, carbon emission but also per capita income significantly resulted in a rise in renewable energy use. Besides, the empirical results highlighted that there was a long-run relationship between renewable energy use and globalization, per capita income, oil price and CO2 emission.

2.4 Smart city, energy consumption and economic growth

It is widely acknowledged that smart city refers to using advanced technology as well as data analysis for a better life of its residents. Many scholars argued that smart city was highly related to energy consumption and sustainable growth (Khansari et al, 2014; Carrera et al, 2021; Yan et al, 2023). Khansari et al (2014) carried out a research on the effect of smart cities on household energy consumption. Their results revealed a positive impact of smart city on energy conservation. Moreover, using the CLIOs conceptual model, the authors argued that the process of energy behavior changed, given socio-structural and techno structural context. Yan et al (2023) analyzed the relationship among smart city and green development for a panel data of Chinese prefecture-level cities, spanning from 2003 to 2016. Their empirical results revealed that smart cities significantly promoted green technological innovation. Besides, the authors argued that green development was one of the results of green technological innovation.

3 METHODOLOGY AND DATA

3.1 Methodology

The seminal work of Blackburne III & Frank (2007) and Eberhardt (2012) showed that the standard panel estimator has been highly associated with large dimensions of observation over the cross-sectional units and time periods. This is the result of the availability of macro data up to 60 years (Eberhardt, 2012). Although larger observations allow research to provide more useful insights, many issues emerge, such as non-stationary, cross-section dependence and cointegration. Ignoring these problems may cause biased results. In this study, we use various advanced econometrics methods to detect these issues before conducting Granger causality test to find the direction of influence among the variables of interest.

3.1.1 Testing for cross-sectional dependence

Cross-sectional dependence test can be dated back to Breusch and Pagan (1980) LM test. However, the test is not suitable for panel data with a large number of cross-section units (Tugcu, 2018). Pesaran (2004, 2015) suggested CD-test for cross-sectional dependence as an alternative. The statistics of the Pesaran's CD-test is calculated as follows:

$$CD = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\sqrt{T_{ij}}\,\hat{\rho}_{ij} \rightarrow N(0,1)$$

where $\hat{\rho}_{ij}$ indicates the correlation coefficients of the residuals. The equation shows the statistics of the Pesaran's CD-test is asymptotically normally distributed as sample size goes to infinity.

3.1.2 Testing for stationary

The unit-root testing framework for panel data can be classified by cross-section dependence. With the assumption of the residuals of cross-section units are independent, Levin et al (2002), Breitung (2000) and Hadri (2000) assume that there is a common unit root process. On the other hand, Pesaran (2007) conducted a t-test to determine the presence of unit roots in panels with cross-section dependence and heterogeneity. Pesaran (2007) considered the cross-section averages of lagged levels and first-difference of the individual series to eliminate the cross dependence. The test statistics is as follows:

$$CIPS = N^{-1}\sum_{i-1}^{N} CADF_i$$

where N is the number of the panels. The CADF-statistic involves the following equation:

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \theta_i \bar{y}_{t-1} + \sum_{j=0}^{p}\delta_{ij}\Delta\bar{y}_{t-j} + \sum_{j=0}^{p}\gamma_{ij}\Delta y_{it-j} + \varepsilon_{it}$$

Where $\bar{y}_{t-i}$ and $\Delta\bar{y}_{t-i}$ denote the cross-section averages of lagged levels and first-difference, respectively.

3.1.3 Testing for cointegration

Tugcu (2018) argued there is a long-run relationship between the variables are not level stationary. This is because the combination cancels out the stochastic trends in the series (Gujarati, 2009). Granger (1986) stated conducting the test for cointegration was meaningful to avoid spurious regression. To examine the existence of long-run relationship among the variables of interest, we use the Westerlund (2005) test which allow for cross-section dependence. The below model is employed to test cointegration.

$$\Delta y_{it} = c_i + \alpha_i (y_{it-1} - \beta_i x_{it-1}) + \sum_{k=1}^{p}\alpha_{1i}\Delta y_{it-k} + \sum_{m=1}^{p}\beta_{1i}\Delta x_{it-m} + \varepsilon_{it}$$

where α_i denotes the speed of adjustment. The null hypothesis is of is of α_i = 0 for all panels whereas the alternative hypothesis is of α_i < 1 for at least one panel (Westerlund, 2005). If the null hypothesis is rejected, it suggests an equilibrium long run relationship.

3.1.4 Testing for Granger causality

With the aim of investigating the causality effect of economic growth and financial development on energy consumption, we use the following model, suggested by Dumitrescu & Hurlin (2012), for studying Granger causality in a panel context. Further, the topic related aggregated total energy consumption has attached great attention by scholars (Aslan and Topcu, 2018), we contribute to the relevant literature through disaggregating total energy consumption by renewable energy consumption and non-renewable energy consumption.

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K}\gamma_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K}\beta_{(i)}^{(k)} x_{i,t-k} + \varepsilon_{it} \quad (1)$$

where *y* and *x* are stationary process, $K \in N^*$ and K is identical across cross-section units, $\beta_i = (\beta_{(i)}^{(1)}, \dots, \beta_{(i)}^{(k)})'$. We assume the individual effect - α_i - to be fixed in the time dimension. Following Dumitrescu & Hurlin (2012), we further assume that $\gamma_{(i)}^{(k)}$ and $\beta_{(i)}^{(k)}$ vary by groups. Besides, the error term - ε - is independent and normally distributed. These assumptions allow the Dumitrescu & Hurlin (2012)'s test to outweigh other causality tests. According to the authors, the null hypothesis is of no individual causality from *x* to *y* and the alternative hypothesis is of there is a subgroup of individuals for which there is no causality relation and a subgroup of individuals for which the variable *x* Granger causes *y*.

In this study, the general equation (1) can be rewritten in the specific ways as follows:

$$lnTEC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnTEC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K}\beta_{(i)}^{(k)} lnG_{i,t-k} + \varepsilon_{it} \quad (2)$$

$$lnTEC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnTEC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_{(i)}^{(k)} lnFD_{i,t-k} + \varepsilon_{it} \quad (3)$$

$$lnREC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnREC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_{(i)}^{(k)} lnG_{i,t-k} + \varepsilon_{it} \quad (4)$$

$$lnREC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnREC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_{(i)}^{(k)} lnFD_{i,t-k} + \varepsilon_{it} \quad (5)$$

$$lnNREC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnNREC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_{(i)}^{(k)} lnG_{i,t-k} + \varepsilon_{it} \quad (6)$$

$$lnNREC_{i,t} = \alpha_i + \sum_{k=1}^{K} lnNREC_{(i)}^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_{(i)}^{(k)} lnFD_{i,t-k} + \varepsilon_{it} \quad (7)$$

where TEC denotes total energy consumption. REC denotes renewable energy consumption. NREC denotes non-renewable energy consumption. G denotes economic output. FD denotes financial development.

3.2 Data

We collect data from the World Bank for economic growth, energy consumption and from the International Monetary Fund for financial development. The time period spans from 1994 to 2014.

4 RESULTS AND DISCUSSION

This section shows our empirical findings. As discussed, we present results in order, from cross-sectional dependence test to stationary test to cointegration test and to Granger causality test. In each table, we use various abbreviations. For example, TEC denotes total energy consumption. REC denotes renewable energy consumption. NREC denotes non-renewable energy consumption. G denotes economic output. FD denotes financial development. Besides, p value is given in parentheses. *** significant at 1% confidence level. ** significant at 5% confidence level. * significant at 10% confidence level.

4.1 Results of cross-sectional dependence test

Our empirical findings provide evidence on cross-section dependence. This is because the null hypothesis of cross-section independence is rejected. In this paper, we use the method of Pesaran (2004, 2015) to check correlation among cross-section units. Details are shown in table 1.

Table 1: The results of cross-sectional dependence test.

	Pesaran (2004, 2015) test	
	CD test	p-value
TEC	78.479***	(0.000)
REC	0.178	(0.859)
NREC	86.556***	(0.000)
G	154.908***	(0.000)
FD	80.898***	(0.000)

4.2 Results of stationary test

Our empirical results show that all the variables used in the model (total energy consumption, renewable energy consumption, non-renewable energy consumption, economic growth and financial development) are not level stationary, but their difference is stationary. That is, they are I(1). Table 2 shows empirical results, which is derived from the method of Pesaran (2007). Details are as follows.

Table 2: The results of stationary test.

	Panel A: Level	
	Constant	Constant & Trend
TEC	0.871 (0.808)	1.704 (0.956)
REC	0.714 (0.762)	2.235 (0.987)
NREC	-0.446 (0.328)	1.261 (0.896)
G	-0.545 (0.293)	33.623 (1.000)
FD	0.513 (0.696)	-0.923 (0.178)
	Panel B: First difference	
	Constant	Constant & Trend
TEC	-8.876*** (0.000)	-7.396** (0.012)
REC	-10.004*** (0.000)	-8.048*** (0.000)
NREC	-10.259*** (0.000)	-7.440** (0.014)
G	-5.261*** (0.004)	-3.736*** (0.000)
FD	-12.941*** (0.000)	-10.755*** (0.000)

4.3 Results of cointegration test

Besides, we found that the variables used in the model are cointegrated. Our claim is supported by using the method developed by Westerlund (2005), Kao (1999) and Pedroni (1999, 2004). Details are shown in table 3.

Table 3: The results of cointegration test

	Panel A: The results of cointegration test for Eq (2)-(4)		
	Equation (2)	Equation (3)	Equation (4)
Westerlund test			
Variance ratio	-1.710** (0.043)	1.934** (0.026)	-0.968 (0.166)
Kao test			
Modified Dickey-Fuller t	2.717*** (0.003)	2.633** (0.004)	2.586*** (0.004)

Augmented Dickey-Fuller	2.846*** (0.002)	3.204*** (0.000)	2.013** (0.022)
Pedroni test			
Modified Phillips-Perron t	2.244** (0.012)	3.737*** (0.000)	2.055** (0.019)
Augmented Dickey-Fuller t	-4.131*** (0.000)	-1.062 (0.143)	-1.741** (0.040)
Panel B: The results of cointegration test for Eq (5)-(7)			
	Equation (5)	Equation (6)	Equation (7)
Westerlund test			
Variance ratio	1.743** (0.040)	-2.995*** (0.001)	2.045** (0.020)
Kao test			
Modified Dickey-Fuller t	2.607*** (0.004)	-1.272* (0.100)	-0.306 (0.379)
Augmented Dickey-Fuller	1.943** (0.026)	1.416* (0.078)	2.364*** (0.009)
Pedroni test			
Modified Phillips-Perron t	2.830*** (0.002)	1.174 (0.120)	2.227*** (0.000)
Augmented Dickey-Fuller t	0.802 (0.211)	-5.763*** (0.000)	-3.225*** (0.000)

4.4 Results of Granger causality test

Finally, as discussed, we conduct the causality test, developed by Dumitrescu & Hurlin (2012). Details are shown in table 5. Our empirical findings provide evidence on unidirectional causality running from economic growth to total energy consumption; unidirectional causality running from financial development to total energy consumption; unidirectional causality running from renewable energy consumption to financial development; and unidirectional causality running from non-renewable energy consumption to economic growth.

Figure 1: The results of Granger causality

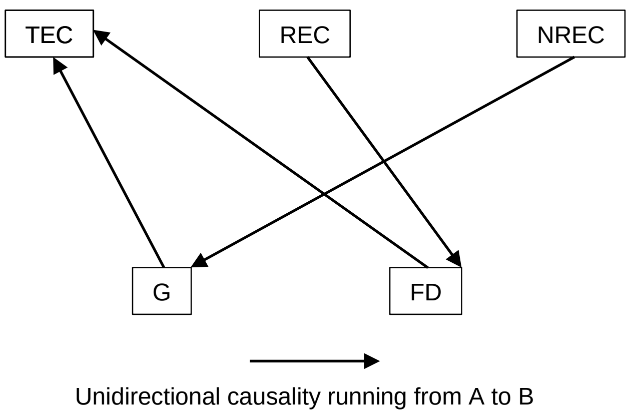

Table 4 The results of Granger causality

X Granger causes Y	*Statistics* Z-bar	Z-bar tilde	Conclusion
G → TEC	2.769*** (0.005)	1.549 (0.121)	Unidirectional causality running from G and TEC
TEC → G	1.184 (0.236)	0.309 (0.757)	
FD → TEC	-0.273*** (0.000)	-0.831 (0.405)	Unidirectional causality running from FD and TEC
TEC → FD	0.708 (0.478)	-0.063 (0.949)	
G → REC	1.366 (0.171)	0.451 (0.651)	No causality between G and REC
REC → G	0.943 (0.345)	0.121 (0.903)	
FD → REC	-0.609 (0.542)	-1.094 (0.273)	Unidirectional causality running from REC and FD
REC → FD	8.954*** (0.000)	1.870* (0.061)	
G → NREC	1.244 (0.213)	0.356 (0.721)	Unidirectional causality running from NREC and G
NREC → G	2.094** (0.036)	1.021 (0.306)	
FD → NREC	-0.422 (0.672)	-0.948 (0.342)	No causality between FD and NREC
NREC → FD	0.555 (0.578)	-0.182 (0.855)	

5 CONCLUSION

With the aim of investigating the causality effect of economic growth and financial development on energy consumption in middle-income countries from 1994-2014, we use the most advanced econometrics techniques for panel data, which identify cross-section dependence, non-stationary. Our empirical findings highlight that: (1) there is cross-sectional dependence; (2) all the variables used in the model are not level stationary, but their difference is stationary (I(1)); (3) there is a long-term relationship between the variables of interest.

Effective energy management policies are essential for reducing energy consumption and promoting sustainable development in smart cities. Energy consumption is a major contributor to greenhouse gas emissions, which are responsible for climate change and other environmental problems. In addition, energy costs can be a significant burden on businesses and individuals, and reducing energy consumption can lead to significant cost savings. By adopting a comprehensive approach to energy management, cities can create a more sustainable and resilient energy system that benefits both the environment and their citizens.

Governments can implement a range of policies to encourage households to manage energy efficiently in smart cities in the context of the 4.0 technology revolution in the context of household level and business level.

In relation to household level, one important policy is to set energy efficiency standards for appliances and promote the use of energy-efficient technologies like smart thermostats and LED lighting. This can reduce energy consumption in households and promote sustainable development.

First, smart home technologies can also be promoted, which use sensors to detect occupancy and adjust energy use accordingly.

Second, governments can offer energy audits to households to identify areas of high energy usage and promote energy-saving practices. This can help households reduce their energy consumption and save money.

Third, Encouraging the use of renewable energy sources like solar panels can also be effective, as can providing energy education to raise awareness and promote energy-saving practices.

Finally, time-of-use pricing can be implemented, charging households different prices for electricity use depending on the time of day, which can encourage households to shift their energy use to off-peak hours and reduce peak demand on the energy grid. These policy suggestions can help households manage energy efficiently and promote sustainable development in smart cities.

Here are some policy suggestions for businesses to manage energy efficiently.

First, governments can offer energy audits to businesses to identify areas of high energy usage and promote energy-saving practices. This can help businesses reduce their energy consumption and save money.

Second, tax incentives and subsidies can be offered for businesses that invest in energy-efficient technologies like LED lighting and smart HVAC systems. To reduce energy consumption in the building sector and promote sustainable development, governments can establish green building codes that require new buildings to meet certain energy efficiency standards. Governments can encourage businesses to use renewable energy sources such as solar panels or wind turbines by offering incentives and subsidies. This can help increase the use of clean energy and reduce greenhouse gas emissions.

Third, to help reduce stress on the energy grid, governments can implement demand response programs that offer incentives for businesses to reduce their energy consumption during peak demand periods.

Finally, governments can partner with businesses to develop energy-efficient solutions and technologies. This can encourage innovation and collaboration in the pursuit of sustainable development.

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