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An Institutional-Based Governance Framework for Energy Efficiency Promotion in Small Island Developing States

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Abstract: Energy efficiency and conservation policy continues to take the proverbial “backseat” to energy access and renewable energy policy discourses in small island developing states (SIDS). In this study, we intend to motivate the energy efficiency policy agenda to encourage more action. To do so, we review the current energy challenges in SIDS and the role of energy efficiency in addressing those challenges, discuss the trends in the rate of improvement in energy efficiency in SIDS, exhibit an updated list of energy efficiency programs and initiatives being implemented in SIDS, consider barriers to energy efficiency implementation and set forth a policy-focused plan to accelerate action. Barriers for the adoption of energy efficiency policies continue to be institutional and policy- and governance-oriented; economic and financial; informational; and technical. A four-pronged policy advancement approach tackling initiation, incentivization, information and investment is recommended to tap the potential gains from energy efficiency. We attempt here, based on our findings, to offer a more practically executable plan of action, focusing squarely on combining institutional arrangements, policy requirements and current energy efficiency affairs in SIDS.

Keywords: small island states; energy efficiency; energy conservation; energy policy; institutional frameworks; energy governance



Citation: Shah, K.U.; Raghoo, P.; Surroop, D. An Institutional-Based Governance Framework for Energy Efficiency Promotion in Small Island Developing States. *Climate* **2021**, *9*, 95. <https://doi.org/10.3390/cli9060095>

Academic Editors: Dalia Streimikiene and Tomas Baležentis

Received: 30 April 2021

Accepted: 1 June 2021

Published: 10 June 2021

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1. Introduction

Energy efficiency policy in many developing countries is still considered secondary to energy access and security and this status quo is acute in small island developing states (SIDS) (A list of SIDS can be found here: <https://sustainabledevelopment.un.org/topics/sids/list>, accessed on 2 June 2021). SIDS comprise a heterogeneous group of islands spread in the Indian, Atlantic and Pacific Oceans and the Caribbean regions, which share similar development challenges but are geographically and demographically diverse. Most of the time, SIDS are studied collectively as they have similar economic, social and environmental problems and due to their similar history with colonial powers. Economically, most SIDS have a negative balance of payments, depending mostly on imports for energy, technology and numerous commodities. They have small domestic markets and limited ability to achieve economies of scale; thus, economic sectors are relatively constrained. Even though SIDS produce less than 1% of the global total of greenhouse gases, they are at the forefront of the impacts of climate change, such as rising sea levels [1].

The recent upsurge of studies on SIDS energy challenges in the academic literature attests to the growing attention being paid to issues of energy policy, though research gaps still exist and more efforts are required for this group of countries to accelerate renewable energy development [2]. Prior studies have highlighted the slow development of renewable energy in SIDS and some have shed light on barriers and the policy solutions needed to accelerate progress in renewable energy in those countries, but energy efficiency and conservation practices have hardly been looked at [3–7]. The few studies that have

focused on energy efficiency include Raghoo et al. [8], Suárez et al. [9], Panfil et al. [10], Shah [11] and Reynolds et al. [12]. To stimulate more research into the energy efficiency policy space in SIDS, we present a comprehensive review of the current state of efforts being made.

The remainder of the article is structured as follows: in Section 2, we explore the current energy challenges in SIDS and the role of energy efficiency in addressing those challenges; in Section 3, we discuss the trends in the rate of improvement in energy efficiency in SIDS. We compile the list of energy efficiency programs and initiatives implemented in SIDS in Section 4. Barriers to energy efficiency implementation are discussed in Section 5 and a plan of action to accelerate its development is proposed in Section 6. Lastly, we present our conclusions in Section 7.

2. Energy Challenges and the Role of Energy Efficiency

There are numerous energy challenges that SIDS are faced with and they can be generally grouped into two broad categories: (a) the accessibility of reliable and affordable electricity and (b) a high dependence on fossil fuels (mostly coal and oil) to meet energy needs [4,13,14].

(a) SIDS' electricity access issue

While Mauritius, Seychelles, Maldives and most of the Caribbean SIDS are fully electrified, other SIDS are facing major issues in achieving full electrification in both rural and urban regions. On average, the electrification rate in the Atlantic and Indian Ocean SIDS is 73.6%; in the Pacific SIDS, it is 72.9%; and in the Caribbean SIDS, it is 88.3% [15]. Table 1 shows the electrification rates of all SIDS that had not been fully electrified by 2016, as well as factors that testify to their socio-economic and energy situations. Haiti, Papua New Guinea (PNG), Solomon Islands and Guinea-Bissau have critically low electrification rates, with more than 50% of their population living in energy poverty. Their Human Development Indices (HDI) ranks and GDP per capita rank low compared to the world's average. Most of the unelectrified population live in the rural areas, where demand for electricity is normally low as the inhabitants possess few electrical appliances. Extending the electricity grid to rural regions is a financial burden for utility companies as the low energy demand of the rural population does not produce a favorable return on investment for grid extension [15]. To cover costs of transmission and distribution, the retail price of electricity has to be fixed as higher for rural regions, which leads to affordability issues for rural consumers. Subsidies have to be provided to utility companies but this is a financial burden on the government. The reliability of electricity supply is also an issue for most SIDS—frequent power outages, load shedding and high transmission losses dominate some electrified urban regions. Much emphasis has been put on decentralized energy systems to expand access to electricity in regions where grid extension is not financially viable, but the high upfront costs of these systems, maintenance costs and the absence of the necessary expertise in the region to ensure their continuous functioning are limiting their widespread adoption [15].

(b) SIDS' high dependence on fossil fuels

For electrified regions, electricity is generated mostly by fossil fuels [4]. On average, 80% of energy is imported, leading to high expenditures in SIDS' energy sectors and increased vulnerability to energy security issues. Palau has nearly 28% of its GDP spent on energy imports, Guyana around 21% and Mauritius 10%, making energy imports account for a large part of SIDS' public budgets [7]. Fluctuations in the price of oil on the international market have huge repercussions on SIDS' economies—when the retail price of gasoline and diesel goes up, utility companies enter a financially unstable zone, and businesses tend to lose competitiveness when increasing energy prices are passed onto them, which can lead to closure or loss of jobs depending on the severity of the situation [8]. The Marshall Islands in the Pacific even declared a “state of emergency” over an oil price hike on the international market when it appeared that the country was

unable to import diesel at reasonable prices to operate their generators—a situation that was avoided through the support of the Taiwanese [3]. It is clear that SIDS face tremendous impediments in coping with oil price volatility and cannot mitigate the effects of oil price fluctuations. Efforts to reduce energy consumption and the transition to sustainable energy sources are therefore highly understandable.

Table 1. SIDS that are not fully electrified (Source: Authors’ compilation with data from Refs. [16–18]).

SIDS Country	Electrification Rate (2016) (%)	2019 GDP/Cap (USD/Cap)	HDI (2019)	Energy Use (kgoe/Cap)
<i>Pacific SIDS</i>				
Fiji	98.6	6175.9	0.743	647 (2007)
Papua New Guinea	22.9	2829.2	0.555	nd
Kiribati	84.9	1655.1	0.630	114 (2007)
Micronesia, Fed. States	75.4	3568.3	0.620	nd
Solomon Islands	47.9	2373.6	0.567	130 (2007)
Vanuatu	57.8	3115.4	0.609	159 (2007)
<i>Indian Ocean/Atlantic SIDS</i>				
Guinea-Bissau	14.6	697.3	0.480	67 (2007)
Cape Verde	92.6	3603.8	0.665	217 (2007)
Comoros	77.8	1370.1	0.554	64 (2007)
São Tomé and Príncipe	65.4	1946.6	0.625	265 (2007)
<i>Caribbean SIDS</i>				
Belize	92.2	4815.2	0.716	595 (2005)
Haiti	38.7	1272.5	0.510	394 (2014)
Grenada	92.3	10,808.7	0.779	770 (2007)

Note: *nd*, no data available; kgoe, kilogram of oil equivalent; HDI, Human Development Index. Italics show ‘region’.

(c) The role of energy efficiency

Among other benefits, such as improvements in health, consumer welfare, environmental benignancy, the mitigation of climate change and energy security, energy efficiency is a solution that makes it possible to both increasing electricity access while simultaneously decreasing fuel consumption. This reduces energy import bills and the savings can be injected into electrification programs. To maintain the affordability of electricity to consumers in SIDS, electricity is often subsidized and reducing energy bills allows authorities to decrease the subsidy burden on their economy. Load-shedding occurrences can be minimized as utility companies do not have to drop off part of the load to prevent an overload condition. Moreover, energy-efficient technologies free up megawatts of electricity, often at a lower capital cost than investing in new energy infrastructures which can provide energy services to more people in a timely manner. In Cuba, for instance, within the first six months that the country switched to more efficient compact fluorescent lights (CFLs), electricity consumption was reduced by 3–4% [10], which represented a significant amount of electricity that could sustain the demand of the underserved population. Energy efficiency advances in household appliances can enable the unelectrified population to afford decentralized energy systems due to reductions in the upfront costs of these technologies. As such, energy efficiency projects and practices might be the much-needed solution for the above-mentioned pressing energy issues in SIDS.

3. Are SIDS on Track in Developing Energy Efficiency?

To understand the trend in energy efficiency improvements in SIDS, we consider energy intensity (measured in MJ/2011 PPP USD) and cumulative annual growth rate (CAGR), which are the United Nations Sustainable Development Goal (SDG) indicators for energy efficiency. We use data from the World Development Indicators (WDIs) to capture SIDS’ progress in developing energy intensity. Energy intensity is the amount of energy consumed per unit of economic output, with a decreasing value being indicative

of higher energy efficiency. The CAGR is the rate of change of energy intensity annually and a negative value is desirable, denoting that less energy is consumed per year. It is often argued that energy intensity is not a reliable measure of energy efficiency as small service-based countries with mild climates, like SIDS, would have much lower energy intensities than industrialized countries in cold climates, even if energy is more efficiently utilized in the industrialized countries than on the small islands [19]. However, as the only international measure of energy efficiency, and as SIDS share a certain level of homogeneity in terms of their economic structure, climate and other characteristics, energy intensity can proffer a reliable comparison of energy used and the extent of progress in meeting development goals.

As shown in Figure 1, the rest of the world has been consistent in stepping up the rate of improvement in energy intensity since 1996. There is a slight attenuation for the period 2007–2011 due to the financial crisis, after which the rate of improvement in energy intensity in the world accentuated. Compared to the previous year, the world experienced a 2.9% improvement in energy efficiency in 2015 to 5.27 MJ/USD (2011 PPP), which is very close to the target set under SDG7. However, this cannot be specifically said for SIDS, as their energy intensities have been very erratic over the 1996–2015 period and it is very difficult to predict how energy intensities will further change in the future. Generally, in SIDS, the energy intensity continually increased from 5.37 MJ/USD in 1996 to 5.87 MJ/USD in 2007 and then eventually started to decline, though the pattern is not definite. The decrease in energy intensity for SIDS is remarkable but the annualized change fluctuates annually. There is no systematic and sustained decline in energy intensity for SIDS and, under these conditions, achieving SDG7 is challenging for this group of countries. The factors that explain this erratic trend in energy intensities in SIDS are not definite at this stage. However, for the period 1990–2015, economic growth in SIDS increased constantly at an average of 5.2% per annum (authors' calculations based on data from the World Bank [16]) and this also led to an increase in energy demand. The demand for more energy has mostly been met by fossil fuels (see Figure 2), as the share of renewable energy used to meet final energy consumption declined over the 1995–2015 period. Over the years, lower renewable energy share has increased SIDS' dependence on fossil fuels and exacerbated their energy issues, but a static energy efficiency policy landscape has left the energy consumption pattern in SIDS unchecked which might explain this variation in energy intensity.

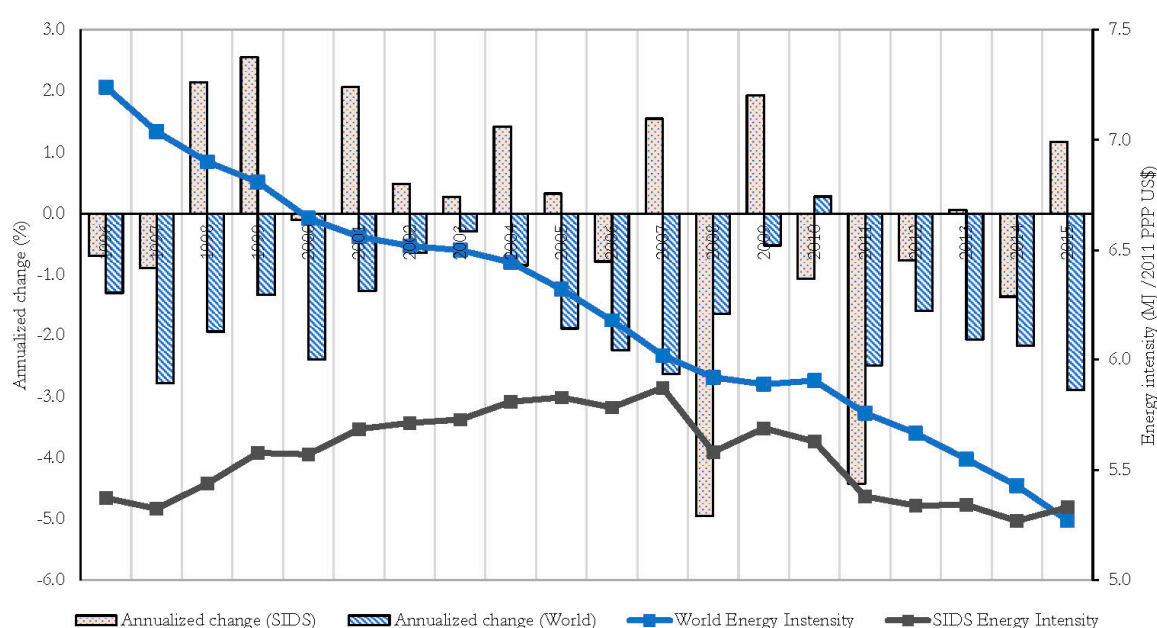


Figure 1. Trend of average energy intensity and annual change in energy intensity, 2000–2015 (Authors' illustration based on data from Ref. [16]).

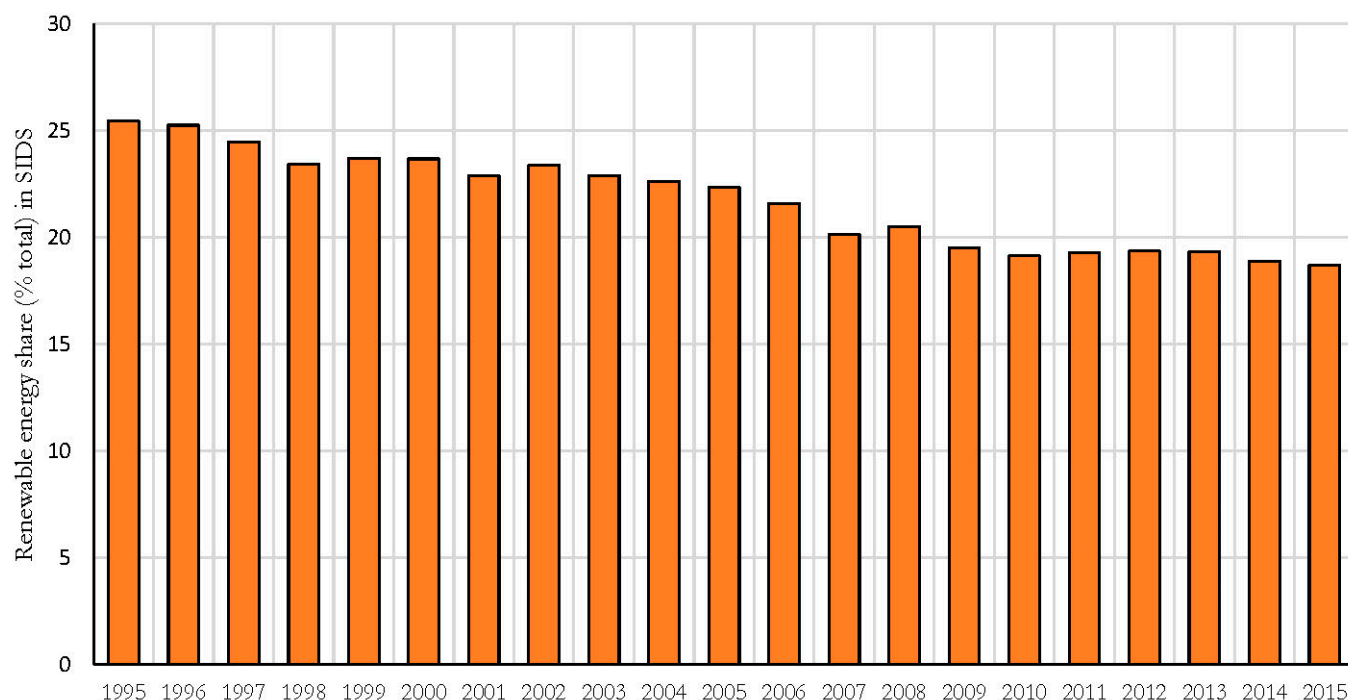


Figure 2. Renewable energy share in SIDS, 1995–2015 (Authors’ illustration based on Ref. [16]).

In Figures 3–5, we show the country-level energy intensities and the CAGR values of SIDS for the period 2000–2015 with data from WDI. Country-level performances vary within and across SIDS regions, ranging from 2.0 MJ/USD in Cape Verde to 12 MJ/USD in Guinea-Bissau for the year 2015. For the sake of analysis, we divide SIDS based on two country blocks—those which had energy intensities less than 5 MJ/USD (relatively “low-energy intensive” SIDS) and those greater than 5 MJ/USD (relatively “high-energy intensive” SIDS) in the year 2000. There were ten SIDS which had energy intensities greater than 5 MJ/USD for the year 2000 and, by 2015, they were all able to reduce their energy intensity to below their 2000 value. The Solomon Islands, Seychelles and Suriname transited from relatively “high-energy intensive” SIDS to “low-energy intensive” SIDS over the 2000–2015 period. Normally, higher energy consumption translates into higher reduction potential in energy intensity, which explains why these states have managed to reduce their energy intensities. For the “low-energy intensive” SIDS, their energy intensities have varied, with Kiribati, Comoros, the Federal States of Micronesia (FSM), Cape Verde and others seeing an increase in their energy intensity.

The potential of improvements in energy intensity cannot be overlooked. On top of the amount of greenhouse gas emissions that were avoided by energy efficiency improvements, the global economy produced an additional USD 40,000 (2011 PPP USD) per MJ in 2015 compared to 2000 [20], which entails huge savings for SIDS’ economic sectors, which are already constrained. SIDS contribute negligible amounts of greenhouse gases to global emissions and energy efficiency improvements in these countries will have a negligible effect on the global greenhouse concentration, but the economic implications behind energy efficiency improvements serve as an incentive in itself for SIDS to exploit this potential in all sectors where energy is used. The rate of energy intensity improvement, as can be seen, is mixed and it is advisable to work towards the achievement of a more systematic decrease in intensities if the energy sector is to be made more dynamic and less dependent on imports of fossil fuels.

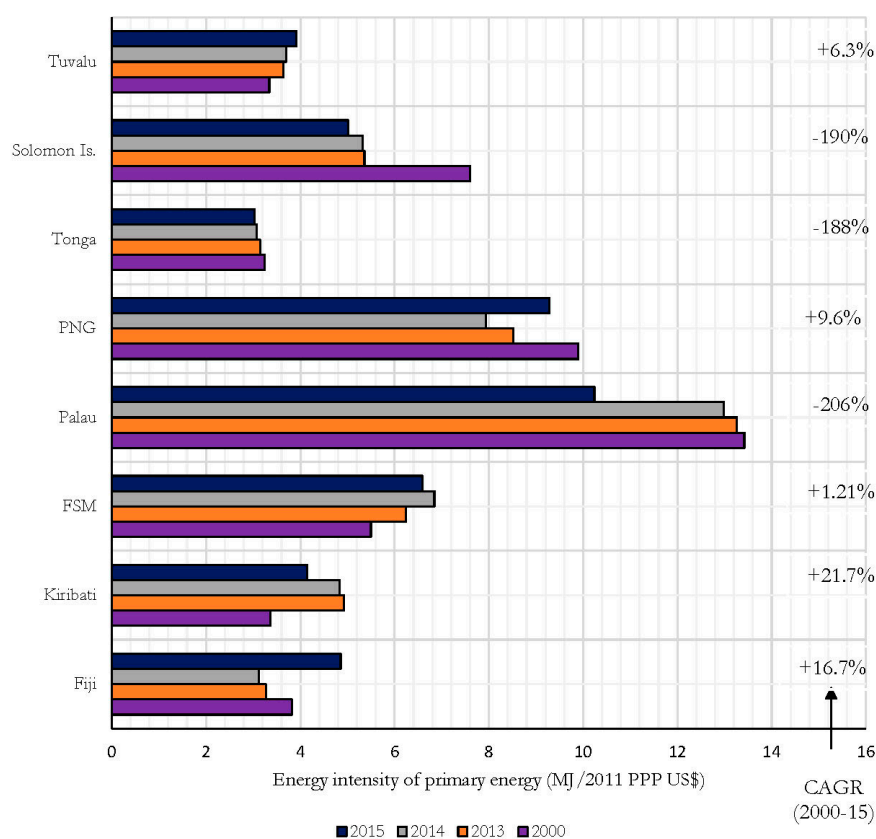


Figure 3. Energy intensity for SIDS in the Pacific regions (Authors' illustration based on data from Ref. [16]).

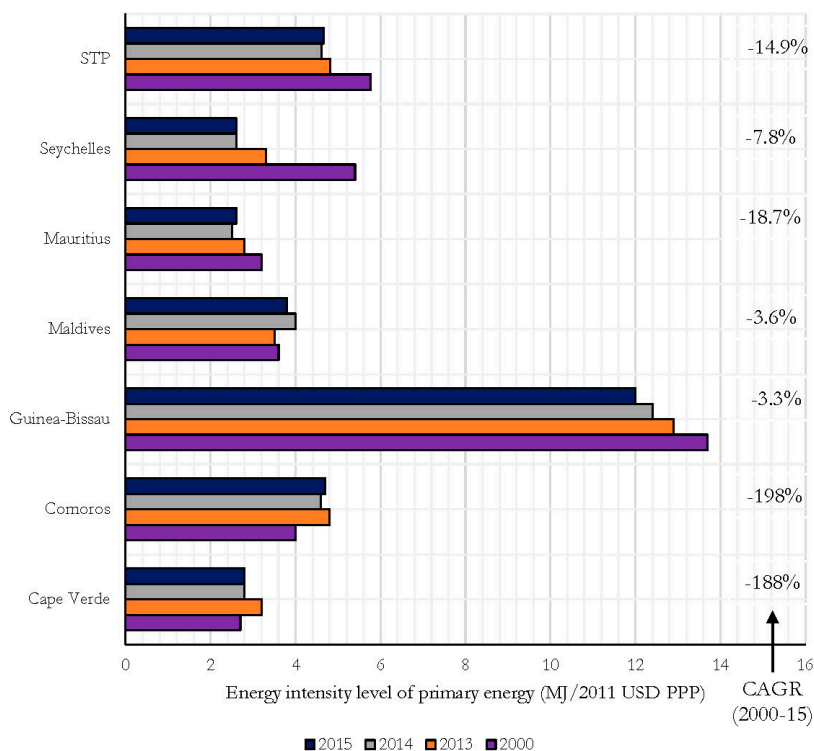


Figure 4. Energy intensity for SIDS in the Indian and Atlantic Oceans (Authors' illustration based on data from Ref. [16]).

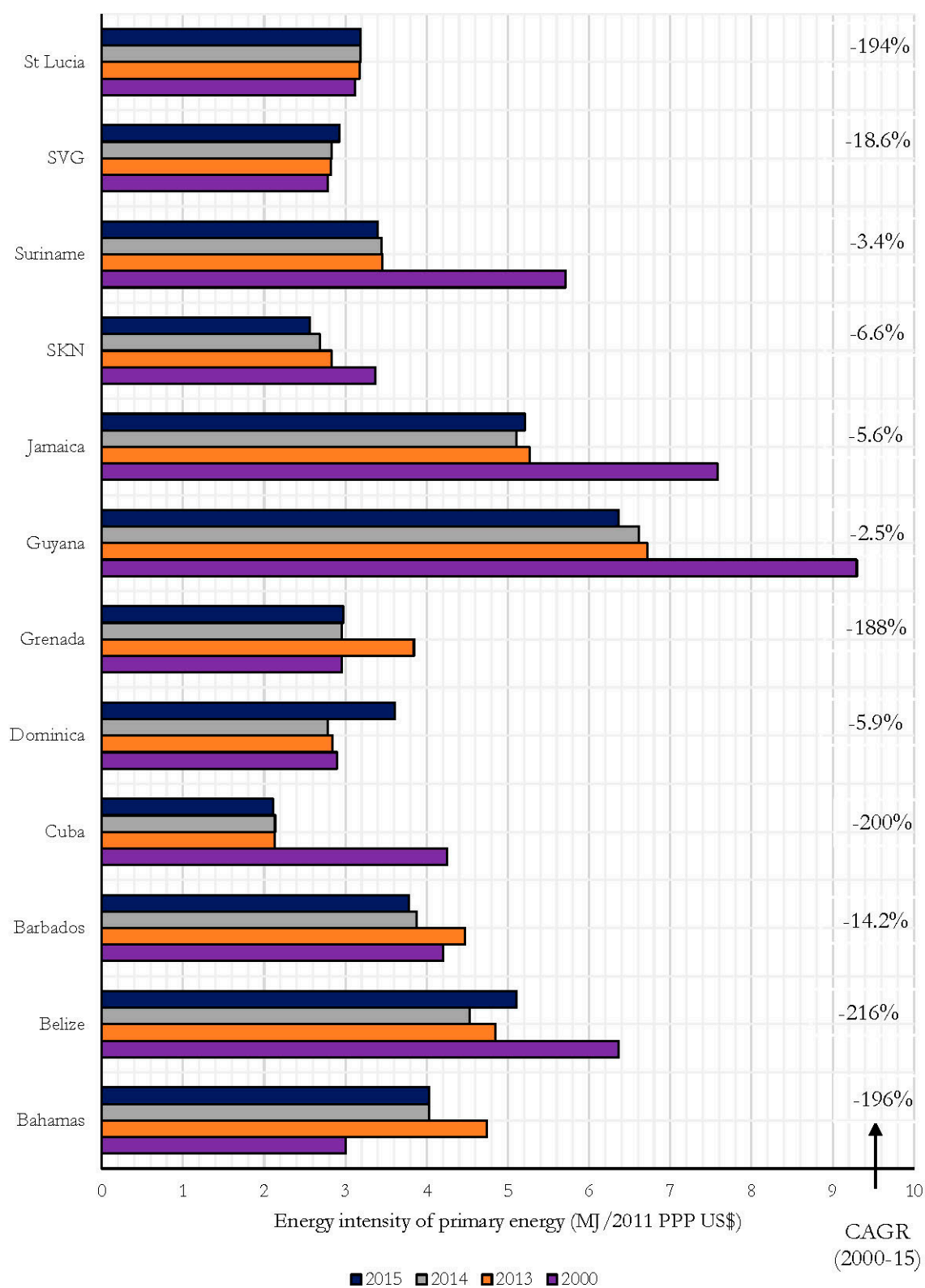


Figure 5. Energy intensity for SIDS in the Caribbean regions (authors' illustration based on data from Ref. [16]).

4. Energy Efficiency Initiatives in SIDS

In Table 2, we present the programs and initiatives implemented in SIDS. The three most commonly deployed energy efficiency programs in SIDS are (a) the replacement of incandescent light with more efficient CFLs, (b) energy labeling and minimum energy efficiency standards for appliances and lights and (c) awareness campaigns. Many developed countries started with these energy efficiency initiatives and eventually moved to implement more impactful and innovative energy savings programs; however, these programs still remain the most commonly deployed in SIDS, which testifies to the slow development in the energy efficiency space in itself.

Lighting takes up a huge portion of the energy consumed by households and many SIDS have initiated projects to substitute incandescent light bulbs with more efficient ones. Incentives were given for incandescent bulbs to be exchanged for high-quality CFL bulbs or for the latter to be purchased at a reasonable price. In Palau, for instance, for the distribution of nearly 10,000 CFL bulbs to 5000 customers in nearly two months, it was expected that the total savings that would accrue to customers would be about USD 180,400 for an investment in the range of USD 15,000–20,000 in the distribution of the CFL bulbs. Palau has benefited from an annual electricity reduction of 820 MWh, which has roughly translated into 110,000 L of fuel saved and also created a market for green products, like CFLs and solar lanterns [21]. In Cuba, a reduction of nearly 3–4% in energy consumption was noted in the first six months after CFLs were introduced [10]. Some SIDS have gone to the extent of banning incandescent lights so that consumers can only purchase more efficient lights on the market [11].

Energy labeling on household electrical appliances is another common regulation in SIDS. Energy labeling is expected to address informational challenges and provide consumers with more information when deciding to purchase a household appliance, and it is an essential program for reducing energy consumption in the residential sector. More energy efficiency appliances are already appearing on the market and SIDS do not need to exert additional efforts to import these appliances. However, it can be challenging for a customer to compare energy efficiency labels during a purchase and there are difficulties for authorities in keeping track of actual efficiency gains. It is also difficult for industrial customers, who may not have a diverse range of purchase options. SIDS have few technically competent authorities to verify and harmonize the energy codes and standards from appliances imported from different countries. In Fiji, it is expected that, for the period 2015–2030, household appliances having energy labels will lead to a 17% reduction in energy consumption under a business-as-usual model [22]. Reports and studies on the efficacy of energy labeling in other SIDS which have adopted such measure are not available.

Table 2. Energy efficiency initiatives and programs in SIDS, 2008–present (Authors’ compilation from Refs. [21–29]). Note: italics show ‘region’.

	CFL Exchange	Ban on Inefficient Lighting	Energy Efficiency Audits	Energy Efficiency in Buildings	Time-Of-Use Tariffs	Solar Water Heating	Products Labeling	Transmission Line Upgrade	Awareness Campaigns	Financial Incentives
<i>Pacific SIDS</i>										
Fiji	x						x		x	
Palau	x					x				
Solomon Is.	x						x			
Vanuatu	x						x			
Kiribati	x						x			
Tonga	x						x			
<i>Indian Ocean/Atlantic SIDS</i>										
Mauritius	x	x	x	x		x	x	x	x	x
Seychelles	x	x	x	x		x	x		x	
Comoros					x				x	
Cape Verde	x	x				x			x	
<i>Caribbean SIDS</i>										
Haiti	x									
Guyana	x								x	x
St. Lucia	x									x
Grenada	x									
Dominican Rep.	x	x							x	
Barbados	x	x				x	x		x	x
Belize	x									
Jamaica	x	x					x		x	
Suriname	x									
Cuba	x						x		x	

Awareness campaigns exist or have existed in many SIDS. The aim of such campaigns is to elicit technological and behavioral changes in the ways energy is consumed, but there are no studies yet that have quantified such savings from behavioral changes. Awareness campaign examples include “billboards”, workshops, television advertisements and essay-writing competitions for school-goers. In Mauritius, the Energy Efficiency Management Office (EEMO) was setup in 2011 with the objective of promoting awareness of energy efficiency in the country. In Guyana, the Guyana Energy Agency promotes a number of “Tip Sheets” in multimedia formats for the public and industry (an example of a pamphlet for an energy-efficient air-conditioner is shown in Figure 6). Awareness campaigns are expected to provide the necessary “nudges” to persuade customers to purchase energy efficiency products, as well as to conserve energy in their daily lives as far as possible [30]. In his survey-based study, Reynolds et al. [12] called for more information dissemination activities regarding energy efficiency in Saint Lucia, as some 40% of Saint Lucian survey respondents still believed that CFLs would not decrease their utility bills and this might affect their willingness to pay for the product. In the eastern Caribbean, Shah [11] found that the negative experiences of the public when using new technologies (poor quality LEDs and CFLs) made them less likely to adopt such technologies later on when better quality products became available.

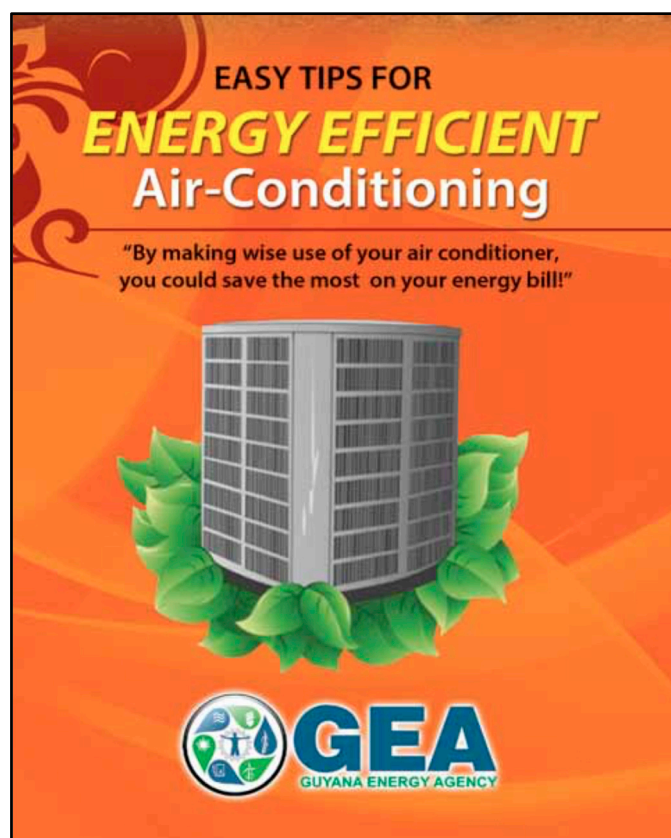


Figure 6. Example of a “Tip Sheet” for the public from the Guyana Energy Agency.

The energy efficiency initiatives listed in Table 2 are not common to all SIDS. The solar water heating project was intended to provide financial incentives to consumers to invest in solar water heaters (SWHs) rather than gas or electric water heaters. Heating is one of the highest energy consumers in a typical household and, by incentivizing people to shift to solar water heating, energy authorities hoped to reduce the load on the grid during peak hours. In Mauritius a grant of 40% of the total cost was awarded to low-income households to purchase SWHs. In the period that the project ran (2008–2013), 58,900 households benefited from it [23]. It was expected that the annual energy savings achieved would

be in the range of 20 GWh/yr [23]. With such an initiative, authorities have set up the groundwork for an SHW market in the country. Installer requirements were developed to ensure high-quality technology, awareness campaigns were conducted and the incentive schemes were deployed as aids to launch the SWH market despite the fact that there are no SWH manufacturers in Mauritius and the technology must be imported. Since 1974, with tax exemptions on the importation of parts for manufacturing, Barbados has been able to supply SWHs to the country and other Caribbean SIDS at an overall low price. It is estimated that 80% of SWHs supplied in the Caribbean come from Barbados and almost 60% of the Caribbean's SWH installations are in Barbados [31,32]. Such projects normally require huge funding or financial incentives for private–public partnerships, which is why they are not widely replicated in other SIDS, but they are rather efficient in creating the necessary conditions for such markets to thrive.

Other programs, like energy audits in hotels and industries or building codes, have not been widely developed. Hotels consume a large amount of electricity and efforts are still ongoing to push for more energy efficiency practices in hotels, but the absence of frequent energy audits makes energy management in hotels difficult [33]. TOU tariffs allow a utility company to charge different electricity tariffs over the course of the day to effectively shift the time for some activities from peak to off-peak time periods and drive significant changes for both consumers and utility companies. Normally, peak demand compels utility companies to fire up kerosene or other standby diesel engines in SIDS to meet peak time demand, which are costly to maintain. With TOU tariffs, electricity rates can be charged at higher prices during peak times so as to compel consumers to shift some of their tasks to later and take advantage of the lower tariffs. Among SIDS, Comoros has such a system installed, in which the electricity tariff is higher at night for medium-voltage customers [34]. Barbados is currently laying the groundwork for implementing a TOU tariff. Barbados Light & Power Company launched a pilot program for the TOU tariff in 2015 but the program encountered a setback due to the limited potential customers enrolled for the pilot program [35].

In an attempt to increase energy efficiency adoption, Guyana, Mauritius, Barbados and a few others have offered some tax incentives to businesses. In Mauritius, the Green Lending Scheme funded by the *Agence Française de Développement* (AFD) is a financial tool that provides small and medium businesses with an 8% rebate on their loans from local banks upon verification of the energy savings made while running the business. In the first round of this project, around USD 44 million from the AFD was fully deployed in 2009 to fund 104 projects and for the second round, in 2014, around USD 66 million was secured. By 2016, half of that amount had been deployed [23]. Besides tax exemptions for the importation of parts for SWHs and other renewable energy systems, the Customs and Excise Department of Barbados provides tax cuts for imports of energy-efficient systems (thermal barriers, roof insulation, windows tints and ceramic roofing coatings) for households (5% exempt), different kinds of energy-efficient lighting (5–20% exempt) and other apparatuses designed to conserve electricity (negotiable duty exemptions) [24]. Furthermore, the Barbados Revenue Authority has some corporate tax holiday exemptions for businesses involved in the manufacture, development and installation of renewable energy and energy efficiency products, as well as for the training of their staff [28]. Guyana has removed taxes on CFL lights and LED lights in an effort to incentivize their uptake in the country but the effectiveness of the policy is not yet known [25].

Supply-side energy management initiatives have also been less common among SIDS, which has resulted in massive technical power losses during transmission and distribution. African SIDS like Comoros and Guinea-Bissau lose over 45% of electricity at substations and over power lines, while Cape Verde and São Tomé and Príncipe (STP) have recorded losses of over 25%. With transmission line upgrades, Mauritius successfully maintained losses at 6.86% in 2014, which was further reduced to 6.56% in 2015 [36]. In the Caribbean, Cuba has recorded technical transmission and distribution losses of around 17% (2014 data) due to poor technology for conductors, Jamaica around 26% (2013 data)

and the Dominican Republic around 12% (2013) [10]. Such system upgrades have been largely ignored by many utility companies, resulting in large power and public funds wastage. Energy efficiency projects in sectors like transportation, industry, commerce and agriculture are rare. In the transportation sector, policymakers in some SIDS are running awareness campaigns to promote non-motorized transport like walking and cycling, as well as ridesharing, public transportation and the importance of regular car servicing for lower fuel consumption. Usage of electric vehicles is still nascent but there are some tax credits given to businesses in Guyana, Barbados and Fiji to develop the market. Since SIDS do not have energy-intensive economies, less attention is paid to energy efficiency practices in the industries they possess. Energy audit support has been given to some manufacturing industries but an appropriate framework for follow-ups and monitoring is lacking. Mauritius conducted 100 energy audits between 2015 and 2016 for which 60% of the cost of the audits was paid by the National Energy Efficiency Program [23]. In the Caribbean SIDS, the CARICOM Regional Organization for Standards and Quality (CROSQ) is instituting numerous building and electrical codes with energy efficiency in mind to make these sectors more energy-efficient [11].

While some of these efforts have been arguably successful in some SIDS, they have not catalyzed a groundswell of widespread energy efficiency regimes with marked impacts on pervasive energy challenges. The initiatives listed in Table 2 are the most common and have been undertaken by many SIDS as they are cost-effective and among the easiest ways to reduce dependence on fossil fuels. Energy efficiency, if adequately exploited, therefore offers an accelerated pathway to sustainable development in SIDS.

5. Barriers to Energy Efficiency Implementation in SIDS

Barriers to the adoption of energy efficiency programs, initiative or policies fall into three broad categories, namely: (a) institutional, policy and governance barriers; (b) economic and financial barriers; and (c) information and technical barriers.

5.1. Institutional, Policy and Governance Barriers

There is a need for appropriate institutions to design, plan, implement, monitor and coordinate energy efficiency projects, information dissemination campaigns, financial incentives, legislations and regulations in the industrial, commercial, hospitality and residential sectors, but these institutions are either non-existent or they lack the necessary resources to perform efficiently in SIDS. Many SIDS rely on energy ministries or departments and utilities companies (which are mostly state-owned in SIDS) for the importation of fossil fuels and the supply of electricity and transportation fuels, energy planning, energy policymaking, energy project financing, the determination of energy prices (electricity and transportation fuels) and energy research [14], and with their already overwhelming responsibilities, it is difficult to provide dedicated attention to energy efficiency initiatives. Existing institutions in SIDS are often understaffed or working staff do not have the necessary skills and expertise to develop energy efficiency projects and policies. The understaffing issue is a barrier in both renewable energy and energy efficiency development that has slowed down the low-carbon development pathway in SIDS, as attested to by a wide range of studies [5,7,14,15,37,38]. The EEMO is one such institution set up by the Government of Mauritius to promote energy efficiency; however, a report from an international consultant (contracted by the government), aimed towards designing a master plan for energy efficiency, also recognized that the EEMO does not have the required spectrum of skills nor sufficient professional staff to carry out the duties of the agency [23]. Regional institutions (e.g., the Secretariat for the Pacific Community or the Caribbean Centre for Renewable Energy and Energy Efficiency under the aegis of the Caribbean Community) are striving to deal with the human resource constraint, including “brain drain”.

The specific location of energy institutions within a government structure can heavily impact their effectiveness. An energy efficiency agency located within an organization which deals with a large array of energy issues will receive little attention and must compete

with other agencies/departments for budgetary funding or other resources [39,40]. Within such locations many renewable energy and energy efficiency promotion institutions in SIDS also face rigid governmental administrative procedures, causing large bureaucratic delays in decision-making and project management. SIDS are parliamentary democracies and, with the turnover of government after elections every five years, ministers and senior officials are replaced frequently (sometimes changed before the end of the mandate); as a result, new administrations tend to reshuffle all of the administrative and bureaucratic processes and apparently lower priority issues, like energy efficiency, lose their position. Due to these frequent turnovers, politicians and policymakers tend to focus on projects that have a huge political leverage and which increase the chances of their reelection; hence, even simple ways through which energy efficiency can be achieved and which can save large amounts of energy are often overlooked in the search for more “visible” projects [41]. Such lack of political will and firm leadership has undermined projects, policies and regulations with regard to energy efficiency in SIDS. These institutional issues also bring another set of problems, such as collaboration and the disruption of communication channels among stakeholders, including financing institutions, private sector consumers and utility companies, among other institutions.

5.2. Economic and Financial Barriers

Some energy efficiency initiatives, like awareness campaigns through television, radio advertisements or billboards, can be undertaken at a relatively low cost, but other, more technical projects require more funding. Funding in developing countries comes from donors, foreign aid grants or concessional loans which are challenging to secure. For allocated funds, policymakers prefer to invest in large energy-efficient projects that provide politicians with political mileage and so investment in renewable energy technologies is prioritized over energy efficiency [42].

With regards to energy-efficient appliances, since SIDS are generally technology importers, the total costs of acquiring these technologies include freights, import duties, sales taxes and insurance, among other fees, and they are thus relatively high compared to what they would be if the technology was locally made. In many cases, the customer decides whether to make a purchase based on the price and models of the appliance and thus energy-efficient appliances with higher price tags tend to be neglected. Businesses also tend to overlook energy efficiency practices and instead apply resources towards activities that enable them to survive; as few energy efficiency investments require high capital costs, businesses are reluctant to proceed in making investments. The problem is exacerbated as there is no guarantee of an adequate return on investment. The payback period to achieve full financial benefits from an energy efficient technology is heavily based on estimates of prospective gains in savings and, as a result, customers and businesspersons are skeptical of making investments in energy efficiency technologies [43]. For this reason, banks find it risky to invest in energy efficiency projects too.

The uncertainty over the future performance of energy efficiency projects also impacts the building and housing sector. It is a principal–agent problem where the agent, who makes decisions on energy efficiency initiatives or projects, does not pay the energy bills and thus has no incentive to undertake such projects. Home builders and home buyers, for example, face this dilemma, as home builders tend to construct apartment complexes with costs kept at a minimum and little consideration for passive building principles, but the payment of the energy bills is left to the home buyers. We thus reach a dilemma where those who can make a difference by building energy-efficient homes do not have any incentive to do so, and those who buy the homes and have an incentive to save on energy bills cannot do anything about it, which is discouraging. Real estate in SIDS is very appealing to buyers from industrialized (colder) countries and, over the last few years, there has been a boom in the real estate sector in countries like Grenada, Bahamas and Fiji. SIDS governments want the investments but such buyers may also introduce luxury levels of living in the islands, including high energy usage.

5.3. Information and Behavioral Barriers

Informational barriers exist across different stages of project development and among different actors. In the industrial and commercial sectors, the full benefits of energy efficiency may not be well-known. There is a lack of data on energy consumption and at the level of the transformation of energy [23]. Even at a household level, customers are reluctant to invest in energy efficiency appliances because of information barriers—that is, there is a lack of understanding and awareness on how energy efficiency works. Under these conditions, concerned actors exhibit some level of skepticism when considering energy efficiency investments. A survey conducted by Singh et al. [44] in African and Pacific SIDS showed that almost 50% of energy practitioners do not have enough knowledge about and expertise in various energy issues, ranging from energy policies and energy legislation to energy management practices, among others.

Lack of information on energy technologies and consumption has also led consumers to use energy in unsustainable ways. Neoclassical economics dictates that customers will purchase energy-efficient products if they get a net monetary gain in return. However, behavioral failures depart from those assumptions and lead customers to forgo purchases of energy efficiency products. Choices are made based on “bounded rationality”. Most of the time, customers do not have complete information about how much energy is consumed, how much energy can be saved through such a practice or technology or the health, environment and money benefits of living an energy-efficient lifestyle. Since energy in the form of electricity is not visible and the savings are “hidden”, consumers tend to have low expectations of what energy efficiency benefits can proffer and, as Shah [11] found in the case of Saint Lucia for CFL lighting, customers are only willing to spend a small amount on “just a light bulb”.

6. Plan of Action—Addressing Energy Efficiency Barriers through Governance

Addressing the barriers of energy efficiency in SIDS is complex and there is no “silver bullet”. There is a need for a combination of legislative frameworks, institutional arrangements and co-ordination mechanisms between the private and public sectors, as well as conducive energy efficiency policies and market-based mechanisms that can promote actions across all sectors where energy is consumed and produced (buildings, housing, transportation, industries, utilities) [45]—with all of these nested in a rational way to support the implementation of energy efficiency initiatives, policies and programs within an energy efficiency delivery system. We call this energy efficiency governance [45–50]. Like many other scholars who have worked on energy efficiency governance to address barriers, we contend that this is a *sine qua non* for addressing barriers to energy efficiency in SIDS. Based on our expert review of the literature, we can identify three core elements that can make up the energy efficiency governance concept for SIDS. These are (a) foundations for governance, (b) targets and goals and (c) a governance action pathway, as shown in Figure 6.

(a) Foundations for energy efficiency governance

The foundations for governance are the resources and structures required to establish an energy efficiency governance system and these encompass institutional arrangements; resources, in terms of people and finances; and political will and support (see Figure 7). Institutional arrangements constitute the “heart” of energy efficiency governance. These arrangements include the administrative and bureaucratic structures capable of performing specialized tasks, such as economic and policy analysis, program planning, policy/program implementation, policy evaluation or program assessment, regulatory responsibilities, project management and financing, general administration and management and co-ordination of training and capacity-building activities, among other tasks [45,47]. There are currently three types of such institutional arrangement models in SIDS, as shown in Table 3, and although we cannot establish which model is preferable, the role of existing institutions can be strengthened or new institutions established by considering: (a) the relative importance of energy efficiency at the national level; (b) the ability to scale-up

energy efficiency; (c) the importance of organizational autonomy, flexibility and agility; (d) funding mechanisms; (e) the level of integration with other clean development goals; and (f) the importance of stimulating public–private partnerships [39]. The benefits and limitations of institutional arrangements choices are provided in Table 3.

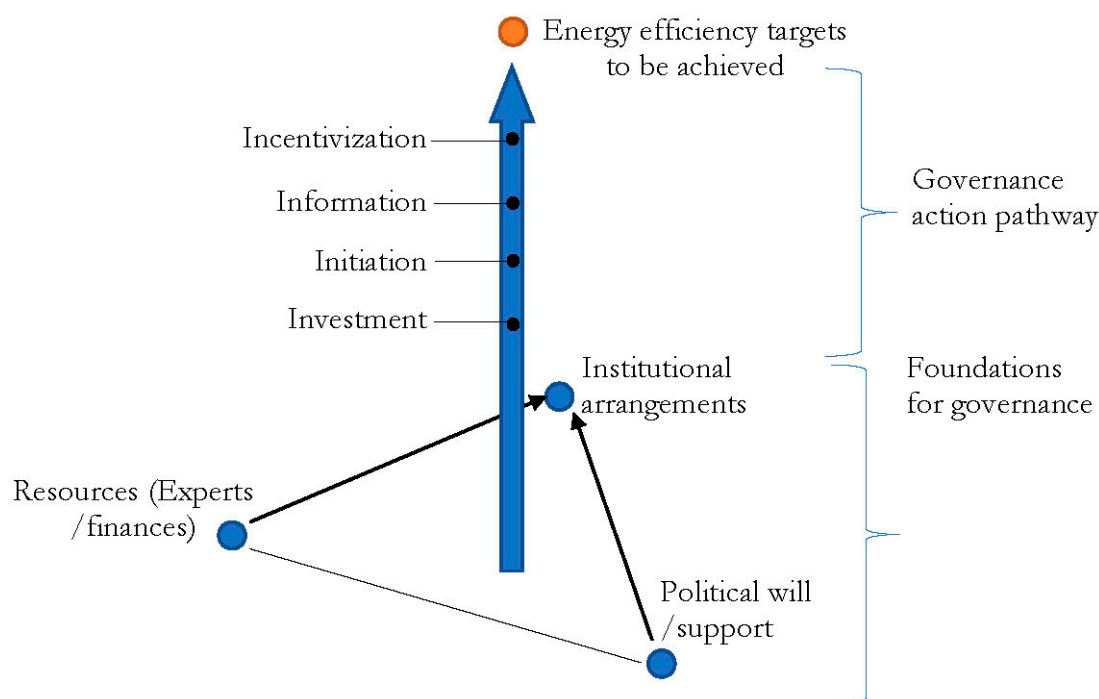


Figure 7. Schematic of proposed energy efficiency governance framework for SIDS (authors’ illustration).

Political will and support are needed to attract high-caliber experts and generate seed investment [15]. Without any essential political backing, it is difficult to mobilize the necessary human and financial resources needed. In terms of financing, SIDS have mostly had “stop–go” funding, where project funds are made available from governments budgets, concessional loans and donors but these are later destabilized by government cutbacks. Better funding mechanisms for SIDS would be a small fee on transportation fuel (Mauritius has levied a 0.6% tax on gasoline to fund renewable energy and an energy efficiency development, which was eliminated in June 2018) or a decrease in the allocation of subsidies for fossil fuels (95% of electricity is subsidized in Fiji and a slightly lower subsidy could be injected into energy efficiency projects) [13].

(b) Targets and goals

The foundation for energy efficiency governance needs to have a target—a quantitative measure—to achieve. Setting targets for renewable energy or energy efficiency has been considered key in deciding “how much” energy efficiency is available and desirable [48]. Energy efficiency targets are useful in motivating policymakers, organizing diverse projects in many sectors at one time, obtaining resources and tracking the results of energy efficiency programs, as well as for identifying the needs for mid-term adjustments [45]. There are many criteria for designing effective energy efficiency targets, which are beyond the scope of this study, but, for the reasons mentioned, a target serves as a key performance indicator that can guide SIDS in their quests towards low carbon economies. Within an energy efficiency governance structure, targets are the achievements to strive for. A few SIDS already have energy efficiency targets in place but monitoring and evaluation activities are largely absent. To make the information available, SIDS’ energy efficiency targets are listed in Table 4.

Table 3. Institutional models in SIDS (Authors' compilation from Refs. [39,45]).

Model	Type	Advantages	Limitations	Example(s)
#1	Governmental agency with broad energy responsibility	Greater credibility among stakeholders Has access to public funding	Competition with other energy programs Competition for management attention Bureaucracy may impede decision-making	Department of Energy (Fiji) Department of Energy (Vanuatu) Ministry of Energy and Energy Industries (Trinidad and Tobago) Palau Energy Office (Palau) Energy Division (Grenada) Division of Energy (FSM)
#2	Governmental agency focusing primarily on "clean energy"	It is easier to attract dedicated staff A dedicated clean energy agency provides a greater voice in policymaking and resourcing	A narrow focus provides less clout Potential for competition between RE and energy efficiency technologies Energy efficiency may or may not get adequate attention	Renewable Energy and Energy Conservation Unit (Barbados) Renewable Energy Unit (Bahamas—no energy efficiency institution) Energy Division (Jamaica)
#3	Governmental agency focusing primarily on energy efficiency	It is easier to attract dedicated staff and dynamic management Better energy efficiency program design Possibility of leveraging other resources (GEF, donors)	A narrow focus provides less clout Success is dependent on effective management	Energy Efficiency Management Office (Mauritius)

Table 4. Energy efficiency targets in SIDS (Authors' compilation from Refs. [25,51–56]).

Country	Target
<i>Pacific SIDS</i>	
Fiji	Energy intensity of imported fuel to be reduced to 2.73 MJ per Fijian dollar by 2030 and energy intensity from power consumption to be reduced to 0.209 kWh per Fijian dollar by 2030
Tonga	None (targets proposed in Energy Efficiency Master Plan; none implemented)
Solomon Is.	Improve energy efficiency and conservation in all sectors by 10.7% by 2020 with an estimated budget of USD 6.29 million
Samoa	None
FSM	Enhance supply-side energy efficiency by 15% and increase the overall energy efficiency by 50% by 2020
<i>Indian Ocean/Atlantic SIDS</i>	
Mauritius	Energy efficiency gains over the 2010–2025 period targeted at 6% by 2020 and 10% by 2025
<i>Caribbean SIDS</i>	
Bahamas	None
Ant. Barb.	20% improvement in energy efficiency by 2020
Barbados	22% reduction in electricity consumption compared to business-as-usual by 2029
Belize	At least 33% improvement in energy efficiency and conservation by 2033
Grenada	None
Dominica	20% reduction in public sector electricity consumption by 2020
Suriname	Reduction of transmission losses below 10% by 2020
Jamaica	None
SKN	Energy intensity reduced by 6.3 million J/USD by 2030 from 22 million in 2015
Saint Lucia	20% reduction in projected electricity demand by 2015 (resulting in peak demand of 45.7 MW)
SVG	20% reduction in public sector electricity consumption by 2020
	5% reduction in projected increase in peak demand by 2015, 10% by 2020; 7% reduction in power losses by 2015, 5% by 2020
	15% reduction in electricity generation by 2020

Note: Ant. Barb—Antigua and Barbuda, FSM—Federated States of Micronesia, SVG—Saint Vincent and the Grenadines, SKN—Saint Kitts and Nevis. Italics show 'region'.

(c) Governance action pathway

The last element of the energy efficiency governance concept is the action pathway. Now that the foundations and targets of energy efficiency governance have been discussed, it is important to delve into the pathway to get to the target set. The pathway to achieve energy efficiency goals is constituted by four "in's", initiation, incentivization, information and investment, as summarized in Table 5, adapted from a framework proposed by Golubchikov and Deda [49] for energy efficiency in the housing sector. With a solid foun-

dation, the conditions are in place to form policies, pass legislations and use market-based mechanisms to promote energy efficiency, as well as allowing resorts to other means of developing energy efficiency if necessary.

Table 5. Barriers and proposed solutions for energy efficiency development in SIDS (Adapted from Ref. [49]).

Proposed Solution	Barriers
Initiation	Lack of political will and leadership Lack of collaboration and communication among stakeholders Institutional and organization barriers
Incentivization	Low priority for energy efficiency in many sectors Principal–agent problem in housing sector Poor enforcement, monitoring and evaluation of energy efficient policies
Information	Lack of information and data on energy consumption and transformation Lack of awareness, knowledge and expertise Behavioral anomalies not accounted for during policymaking
Investment	Uncertainties and risks discouraging private participation Lack of financial capacities Consideration for large projects which necessitate huge funding

The foundations of the energy efficiency governance concept have already initiated a step forward toward accelerating energy efficiency development by mobilizing the political support and restructuring the institutional arrangements needed for such endeavors. Along the pathway for energy efficiency, there is a need for appropriate agencies to initiate collaboration with other developing or developed countries to achieve economies of scale and scope. Collaboration can take several forms—to establish markets for energy-efficient products, for instance, or for research and development, sharing of funds, capacity-building or to pool the skills and expertise needed with other SIDS (inter-government collaboration). There may also be intra-government collaboration to include energy efficiency practices in other government entities.

Incentivization refers to the provision of incentives to all sectors where energy is consumed to achieve a reduction in energy consumption. In the industrial, commercial and hospitality sectors, these incentives can take the form of tax rebates, exemptions or reductions; cost-sharing schemes between the public and private sectors; or voluntary agreements between these sectors. A tax on inefficiency for some sectors can also be levied, compelling users to remediate if the tax is to be avoided [49,57]. Residential energy issues can be overcome by providing subsidies for improved energy efficiency in housing. Conditions for incentives can also include requirements to perform periodic evaluation and monitoring of energy efficiency programs and policies in these sectors and to report data to policymakers for analysis. An energy database where these evaluations can be hosted is a great tool for analysts to further analyze and evaluate data to check if they are in line with targets.

Lack of knowledge, awareness and understanding about the economic, welfare, environmental and health benefits of energy efficiency can be overcome by educational activities and awareness programs. Studies have recognized the weak professional skillset in the energy sector in SIDS and intensive training and capability-building have to be organized if the know-how of energy practitioners working in different disciplines is to be strengthened [8,15,38,44]. Informational campaigns have to be continued across all sectors, especially in such a way as to “nudge” the behavior of consumers and encourage them to make rational consumption choices, conservation actions and investment decisions. Awareness makes energy efficiency more “visible” as a resource.

Lastly, investment can address financial barriers. We have highlighted above that taxes can supply a flow of funds into the governance system to cover operations and administrative costs, as well as awareness campaigns, and low-budget projects and financial

incentives allow the private sector to develop some energy efficiency projects on their own. With the proper institutional milieu and robust financial institutions, additional funding from donors, loans and grants for large projects can be made available as it decreases institutional risks and uncertainties. Governmental agencies can also invest in energy efficiency projects to serve as demonstration projects, e.g., investing in infrastructure to decrease energy consumption in the public sector, constructing a zero-waste building or other projects. Such investments help in making energy efficiency gain priority among banks. In Mauritius, for example, enterprises have found their applications for retrofitting and other energy efficiency projects rejected when they were unable to provide for collateral, even though the projects were of high technical quality and could provide significant savings to pay back loans [23].

7. Conclusions

Energy efficiency holds tremendous potential for helping SIDS to achieve energy security, decrease fossil fuel imports and electrify rural areas, but the resource has been utterly neglected by analysts and policymakers alike. Here, we brought to light the potential for energy efficiency in SIDS, elaborated on the barriers impeding its development and proposed a plan of action that can hopefully accelerate energy efficiency endeavors in SIDS. While most developments towards low-carbon transition have been focused on renewable energy, energy efficiency holds the complementary potential to drive SIDS' energy transition. Trends in energy intensities in the last decade have been rather erratic and decreases in energy consumption have not generally been systematic for SIDS. On a country-level basis, although a decrease in energy intensities has been observed in recent years, the lack of a policy landscape makes it difficult to further develop the energy efficiency sector and accelerate decarbonization. Initiatives, projects and policies are diverse across SIDS and this article offered a comprehensive review of the status quo of energy efficiency in SIDS. A plan of action to achieve energy efficiency was proposed. The plan pushes for better governance of energy efficiency and proposes a governance framework with three elements at its core—a foundational structure, targets and goals and a pathway to achieve the targets. As new evidence emerges, the plan of action can be re-evaluated. Previous studies have mostly listed policy interventions and recommendations while this review and compilation study offers a more practical and executable plan of action, combining institutional arrangements, policy requirements, current energy efficiency affairs in SIDS and other frameworks and ideas from previous studies as deemed appropriate. Clearly, energy efficiency potential in SIDS needs to be exploited if SIDS are to continue along their path towards sustainable development.

Author Contributions: Conceptualization, K.U.S. and P.R.; methodology and validation, K.U.S., P.R. and D.S.; formal analysis, P.R.; writing—original draft preparation, P.R.; writing—review and editing, K.U.S. and D.S.; supervision, K.U.S.; project administration, K.U.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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