



**Manchester  
Metropolitan  
University**

---

Raghoo, P, Surroop, D, Wolf, F, Leal Filho, W, Jeetah, P and Delakowitz, B (2018) Dimensions of energy security in Small Island Developing States. *Utilities Policy*, 53. pp. 94-101. ISSN 0957-1787

---

**Downloaded from:** <https://e-space.mmu.ac.uk/621469/>

**Version:** Accepted Version

**Publisher:** Elsevier

**DOI:** <https://doi.org/10.1016/j.jup.2018.06.007>

**Usage rights:** Creative Commons: Attribution-Noncommercial-No Derivative Works 4.0

Please cite the published version

<https://e-space.mmu.ac.uk>

1  
2 **Deposit copy, published at:**

3 Utilities Policy, **53**: 94-101 01 Aug 2018

4 <https://www.sciencedirect.com/science/article/pii/S0957178717302308?via%3Dihub>

5  
6  
7 **Dimensions of Energy Security in Small Island Developing States**

8 Pravesh Raghoo<sup>a</sup>, Dinesh Surroop<sup>a\*</sup>, Franziska Wolf<sup>b</sup>, Walter Leal Filho<sup>b</sup>, Pratima Jeetah<sup>a</sup>, Bernd

9 Delakowitz<sup>c</sup>

10 <sup>a</sup>University of Mauritius, Department of Chemical and Environmental Engineering, Réduit

11 80837, Mauritius

12 <sup>b</sup>School of Science and the Environment, Manchester Metropolitan University, Chester Street,

13 Manchester M1 5GD, UK & Hamburg University of Applied Sciences, Research and Transfer

14 Centre Sustainability and Climate Change Management, Ulmenliet 20, 21033 Hamburg,

15 Germany

16 <sup>c</sup>University of Applied Sciences Zittau/Görlitz, Institute for Ecology and Environmental

17 Protection, Theodore-Körner-Allee 16, 02763 Zittau, Germany

18 \*Corresponding author: [d.surroop@uom.ac.mu](mailto:d.surroop@uom.ac.mu); +230 403 7819

19  
20 **ABSTRACT**

21 For any Small Island Developing States (SIDS) that imports oil, energy security is very important  
22 and is dealt with seriousness. This paper attempts to look at the gap in the literature and to identify  
23 the dimensions on which a secure and sustainable supply of energy depend in SIDS. Seven  
24 dimensions were identified which offer a framework for conceptualising and/or assessing key  
25 energy security dimensions in small island nations which are import dependent; energy prices;  
26 climate change and resilience; governance; infrastructure; equity; and energy efficiency. This  
27 article provides recommendations of selected strategies and actions to improve energy security in  
28 SIDS.

29  
30 **Keywords** Small Islands developing States (SIDS); Energy security; Strategies

31  
32 **1. Introduction**

33 Energy security has been broadly and incomprehensively defined within scientific literature  
34 (Ebinger, 2011). While some authors conceptualised energy security as relative to economic  
35 development, others studied energy security in terms of energy availability, resource affordability,  
36 environmental sustainability, energy efficiency and technology (APEREC, 2007; Lefèvre, 2010;  
37 Sovacool and Mukherjee; 2011; Cao and Bluth, 2012; Hughes, 2012; Chuang and Ma, 2013;  
38 Selvakkumaran and Limmeechokchai, 2013; Martchamadol and Kumar, 2013; Misila et al., 2015;  
39 Phdungslip, 2015). Kucharski and Unesaki (2015) supported Winzer (2012) and Leal Filho and  
40 Voudouris (2013), who stated that energy security is concerned about risks and vulnerabilities  
41 whether geopolitical risks or natural disastrous events. Cherp and Jewell (2011) discussed  
42 robustness, sovereignty and resilience as three perspectives of energy security. Chester (2010)  
43 discussed the polysemous nature of energy security while referring to other authors' claims on the  
44 vague, elusive, inherently difficult, abstracted and blurred concepts of energy security. Rosen  
45 (2009) looked at the key energy-related steps in addressing climate change.

46 While it is widely agreed that 'energy' refers to both primary (oil, coal, natural gas and renewable  
47 energy) and secondary sources (electricity), a wide range of literature predominantly focuses on  
48 the reliability of oil supply when the topic of energy security is discussed (Vivoda, 2010; Stringer,  
49 2008). Most probably, this is because oil is the most consumed primary energy resource in the  
50 world accounting nearly 33% of the global energy market (BP, 2016; Vivoda, 2010) and because  
51 oil prices are often fluctuating as a result of political instability and conflicts in major oil producing  
52 countries (Asif and Muneer, 2007). Volatile oil prices have negative repercussions on both oil  
53 exporters – as they are faced with varying revenues – and oil importers as they perceive significant  
54 uncertainty on imports costs and fuel subsidy level, and in this context, numerous studies were  
55 conducted to better understand, define and characterise the whole concept of energy security  
56 (Rentschler, 2013; Narula and Reddy, 2016). Policymakers often measure energy security through  
57 a number of energy indicators and indices derived from suitable dimensions or assessment  
58 instruments, which are factors that influence a stable energy supply in a country (Narula and  
59 Reddy, 2015). Hence, Vivoda (2010) proposed 11 dimensions and several attributes to gauge  
60 energy performance, Sovacool (2011) presented 20 dimensions and Von Hippel et al. (2011)  
61 provided six dimensions and numerous attributes and strategies to characterise energy security  
62 performance. Based on these dimensions, a number of authors have developed indices, for  
63 example, Lefèvre (2010) developed the Energy Security Price Index (ESPI), Gupta (2009) came

64 up with the Oil Vulnerability Index (OVI), ex-ante and ex-post indicators by Löschel et al. (2010)  
65 and the Aggregated Energy Security Performance Indicator (AESPI) by Marchamadol and Kumar,  
66 2013 among other researchers. Research on energy security in Small Island Developing States  
67 (SIDS) member states (see Table 1 for list) is of high relevance as they are net energy importers  
68 and are intricated by unique geographic, demographic, economic and environmental challenges  
69 (Blancard and Hoarau, 2013; UNEP, 2014). SIDS are geographically located in the Atlantic,  
70 Indian Ocean, Mediterranean and South China Sea (AIMS), Caribbean and Pacific regions. The  
71 total population in the SIDS in this study is around 61,516,000 with the largest share in the  
72 Caribbean which represents 65% followed by Pacific with 18% and AIMS 17% (World Bank,  
73 2017). However, research on energy security in SIDS is in its infancy and this study is the first of  
74 its kind to come up with relevant indicators of energy security applicable to island states. There  
75 appears to be little progress on indicator development because, so far little has been done to  
76 identify meaningful dimensions on which a stable energy supply in islands depends. The World  
77 Energy Council (2017) developed the world energy trilemma index and reported that there are only  
78 five SIDS in the list of 125 countries assessed. The energy trilemma ranking is based on energy  
79 security, energy equity and environmental sustainability, morerecently taking CO2 emissions into  
80 account (Leal Filho 2015). Denmark is ranked first in the list of 125 countries and the five SIDS  
81 are Singapore - 22<sup>nd</sup>, Mauritius – 47<sup>th</sup>, Dominican Republic – 79<sup>th</sup>, Jamaica – 85<sup>th</sup> and Trinidad &  
82 Tobago – 88<sup>th</sup> (WEC, 2017) The uniqueness of this paper is that, firstly, it develops a conceptual  
83 framing of relevant energy security dimensions of SIDS and secondly, it draws from a review of  
84 some potential initiatives, some recommendations of selected strategies and measures to improve  
85 energy security in SIDS context. The article thus contributes to filling a literature gap on energy  
86 security and seeks to refocus attention to initiate further research for energy sector development in  
87 SIDS.

88 **Table 1.** List of Small Island Developing States (SIDS)<sup>1</sup> (Source: UNEP, 2014)

SIDS region	SIDS countries
-------------	----------------

---

<sup>1</sup> While brief references are made to Papua New Guinea (PNG) and Trinidad & Tobago, the hypothesis elaborated made in this article are less applicable to PNG. PNG and Trinidad & Tobago are energy exporter and energy importers and exporters have different dimensions on which their supply of oil to their population depends. Energy security aspects of oil exporters have to be dealt separately and is beyond the scope of this paper.

AIMS	Cape Verde, Comoros, Guinea–Bissau, Maldives, Mauritius, Sao Tome and Principe, Seychelles, <sup>2</sup> Singapore
Caribbean	Antigua and Barbuda, Bahamas, Barbados, Belize, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St Kitts and Nevis, St Lucia, St Vincent and Grenadines, Suriname, Trinidad and Tobago
Pacific	Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, Vanuatu

89

90 **2. Methods for data collection**

91 Two methodological approaches were simultaneously used to characterise key dimensions of  
 92 energy security that are relevant to SIDS. Firstly, a review of present literature based on energy  
 93 development in SIDS and energy security was conducted. Literature on islands’ energy sector was  
 94 obtained mostly from intergovernmental and think–tank reports. The aim of literature search was  
 95 to identify major energy security dimensions and their applicability in small islands. To support  
 96 some arguments, statistical data from various international databases were collected such as the  
 97 World Development Indicators of the World Bank, the International Disaster Database from the  
 98 Centre for Research on the Epidemiology of Disasters (CRED) and the Electricity Database from  
 99 the International Energy Agency (IEA). Where data was unavailable from these sources,  
 100 information was retrieved from governmental statistical publications, reports from development  
 101 banks, regional agencies and national organisations along with a wide range of peer–reviewed  
 102 papers. Efforts have been made to gather, as far as possible, the most up–to–date data. Accuracy  
 103 and authenticity of the data collected was maintained by cross–checking with other statistical  
 104 reports.

105 Secondly, to consolidate the findings of the literature review, a qualitative survey was carried out  
 106 among energy practitioners in Mauritius, Fiji, Samoa, Vanuatu, Tonga, Tuvalu and Federated  
 107 States of Micronesia. The survey was carried out in 2014 as part of the L<sup>3</sup>EAP Project  
 108 (www.project-l3eap.eu) which aims to develop and provide lifelong learning approaches and

---

<sup>2</sup> Singapore is not a developing state but a developed country, but is part of the SIDS group. The findings in this study can equally be applicable to Singapore as the country share similar environmental and economic challenges as other SIDS members

109 strengthen local capacities on energy access, security and efficiency in SIDS. Respondents were  
110 chosen purposively and constituted of energy professionals working for non-governmental  
111 organisations (NGOs), the private and public sectors, utility companies and renewable energy  
112 agencies. The survey received 32 respondents from Mauritius and 29 from the Pacific Island  
113 Countries (PICs) – 61 in total. From PICs, 4 participants were energy analysts from the  
114 Department of Energy, 12 participants were from NGOs, 7 participants from utility companies and  
115 6 from private companies working in the energy domain. In Mauritius, 28 participants were from  
116 the power producing companies, 3 from utility companies and 1 from a research institution. Most  
117 respondents search for securing energy resources as part of their professional responsibility.  
118 Respondents with practical knowledge of energy security was sought rather than experts with  
119 predominantly theoretical knowledge. Survey in the Caribbean islands could not be conducted but  
120 views from participants can presumably be extended to reflect the energy security issues and  
121 dimensions in the Caribbean islands. Respondents were asked basic bio-data information and to  
122 give their views on ‘energy security’ in open-ended questions.

123

### 124 **3 Data analysis and discussion**

125 Responses obtained were processed as per Miles and Huberman (1994) and Patton (2002) and as  
126 previously applied in Blumer et al. (2015). Recurrent themes from the wide range of views from  
127 the survey were used to develop a set of codes which were labelled as (i) import dependency, (ii)  
128 energy prices, (iii) climate change and resilience, (iv) governance, (v) energy infrastructure, (vi)  
129 equity and (vii) energy efficiency. Some responses, such as one energy expert said: “Energy  
130 security has two key dimensions – reliability and resilience is attributed to two codes; “reliability”  
131 attributed to code (i) and “resilience” to code (iii).

132 Results has been simplified as in Table 2 which gives the proposed dimensions for a secure energy  
133 system in SIDS and the percentage recurrence in the responses of the survey sample. The  
134 percentage recurrence is the number of parameters applicable to a particular code divided by the  
135 total number of codes recorded. Most experts claimed *import dependency* and *affordable energy*  
136 *prices* as mandatory parameters for a secure energy system in islands. This is not surprising as  
137 these two dimensions figure in a wide range of literature. In most scientific literature, these two  
138 terms are known as ‘availability’ and ‘affordability’ of energy.

139 The survey results showed *climate change and resilience* among the top three priorities for a secure  
 140 energy system in islands. It is important to highlight a piece of observation: contrasting these  
 141 results with a study by Ang et al. (2015) who ranked *environment* fifth from a wide range of studies  
 142 on energy security from developed countries namely China and Japan, the problem of climate  
 143 change is more pronounced in SIDS. Other important dimensions identified by experts are  
 144 governance, energy infrastructure, equal energy distribution and energy efficiency which are  
 145 further commented in the next section.

146 **Table 2.** Survey results from open-ended question and percentage recurrence in responses

Some Keywords/phrases	Dimensions	Percentage
Availability; adequate; reliability; Consistent	Import dependency	46%
Reasonable and affordable prices; economic performance	Energy prices	15%
Clean energy; sustainability; resilience; shocks; withstanding threats; external forces	Climate change and resilience	14%
Management of energy supplies; requirements of a nation	Governance	8%
Generation and distribution system; fuel storage facilities	Energy Infrastructure	6%
Equal distribution; the right; not discriminated against	Equity	6%
Efficient; intelligent use	Energy efficiency	3%

147

148 **4 Dimensions of energy security in SIDS**

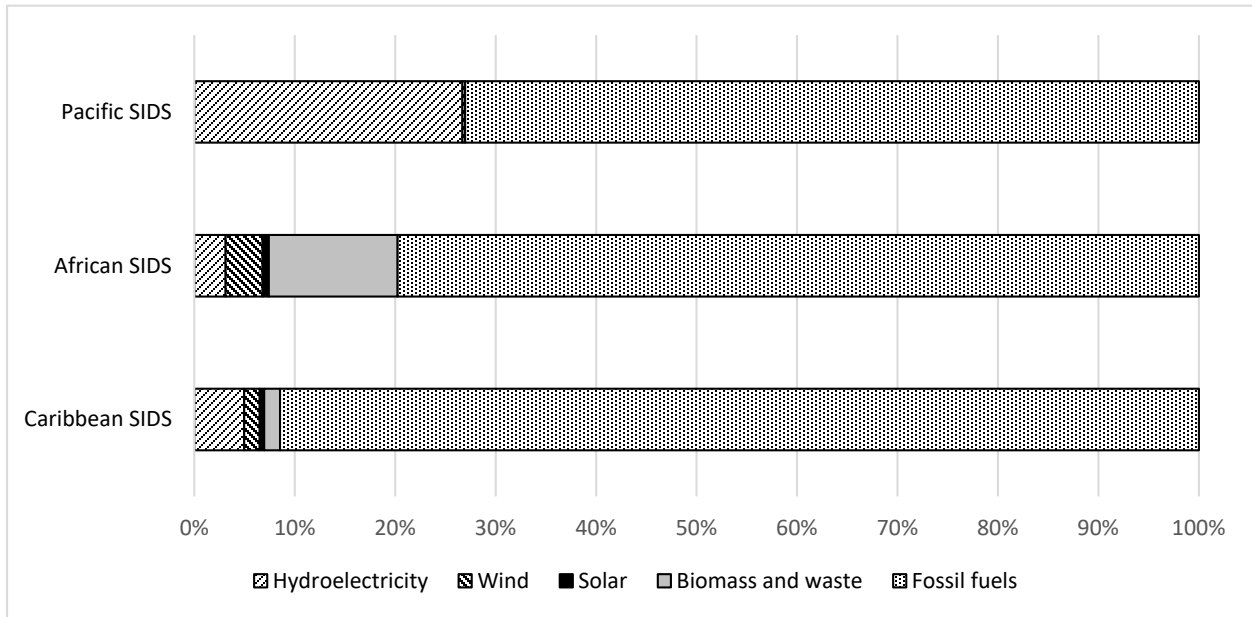
149 *4.1 Import dependency*

150 Based on the survey, it was noted that the first and most important dimension which characterise  
 151 energy security in SIDS is import dependency. In general, SIDS are net oil importers. Most energy  
 152 practitioners agreed that oil import to SIDS countries encompasses all other energy security  
 153 dimensions which is spearheaded by their high consumption. Fig. 1 show the electricity mix in

154 Africa, Caribbean and Pacific SIDS and as observed over 70% of energy demand for electricity is  
155 satisfied by fossil fuels which are imported. They explained that high dependency on oil exposes  
156 SIDS to the direct risks of supply disruptions and possible effective solutions (such as source  
157 diversification) are not economically feasible in SIDS context. Country-wise, Suriname,  
158 Dominica, Fiji, Belize, Cape Verde and Sao Tomes and Principe have diversified energy mix by  
159 deploying sustainable energy sources like wind and hydro to enhance energy security, but  
160 renewable energy development in SIDS is still constrained by a number of barriers as Timilsina  
161 and Shah (2016) discussed in their paper. Raghoo et al. (2017) studied the feasibility of  
162 diversifying the energy mix by importing natural gas from neighbouring countries but the  
163 possibility of supply disruption remains. Alternatively, source modification can be sought to  
164 improve energy security (APEREC, 2007). Instead of importing oil from only one country, oil  
165 importers can purchase oil from different countries and thus mitigate the risks of supply disruptions  
166 (Ang et al., 2015). However, source diversification has its limitations over geographical distance,  
167 political relationships with exporting countries, energy policies and the resources required to  
168 implement those policies (Vivoda, 2009). Source diversification seems more an ‘elusive’ concept  
169 as SIDS import relatively small amount of oil over long distance. In Mauritius, petroleum products  
170 are imported from Mangalore Refineries and Petrochemicals Ltd on a 22–day shuttle over 4600  
171 km. Importing oil from different suppliers can increase energy expenses directly impacting the  
172 domestic sale of oil.

173





**Fig. 1.** Electricity generation mix in Pacific, African and Caribbean SIDS, 2015 (Source: authors’ illustration from data from EIA, 2015)

175

176

177

178

179 *4.2 Energy Prices*

180 The second factor that the survey revealed influencing energy security in SIDS is energy prices.

181 Energy practitioners discussed how energy prices as an economic dimension, influence energy

182 security. Being small and having a negligible oil demand on the international market, SIDS have

183 less control on the price of goods they import and export and are therefore, ‘price-takers’ rather

184 than ‘price-setters’ (Briguglio, 1995). Since SIDS are sea-locked, they rely extensively on air or

185 maritime transport for imports and exports. Freight costs are unusually high because SIDS lie

186 outside the conventional zone where most ships circumnavigate. This increases oil expenditures

187 in SIDS where often oil imports is a fraction of country’s overall GDP. Fig. 2 provides GDP share

188 dedicated to oil imports in selected SIDS for which data is available, where this fraction is as high

189 as 28% in Palau. Being highly reliant on oil makes SIDS susceptible to oil price shocks. In a

190 study, Bacon and Kojima (2008) showed that the changes in economic susceptibility, that is, the

191 variations in the share of GDP accounted by the importation of oil from 1996 to 2006, in Guyana

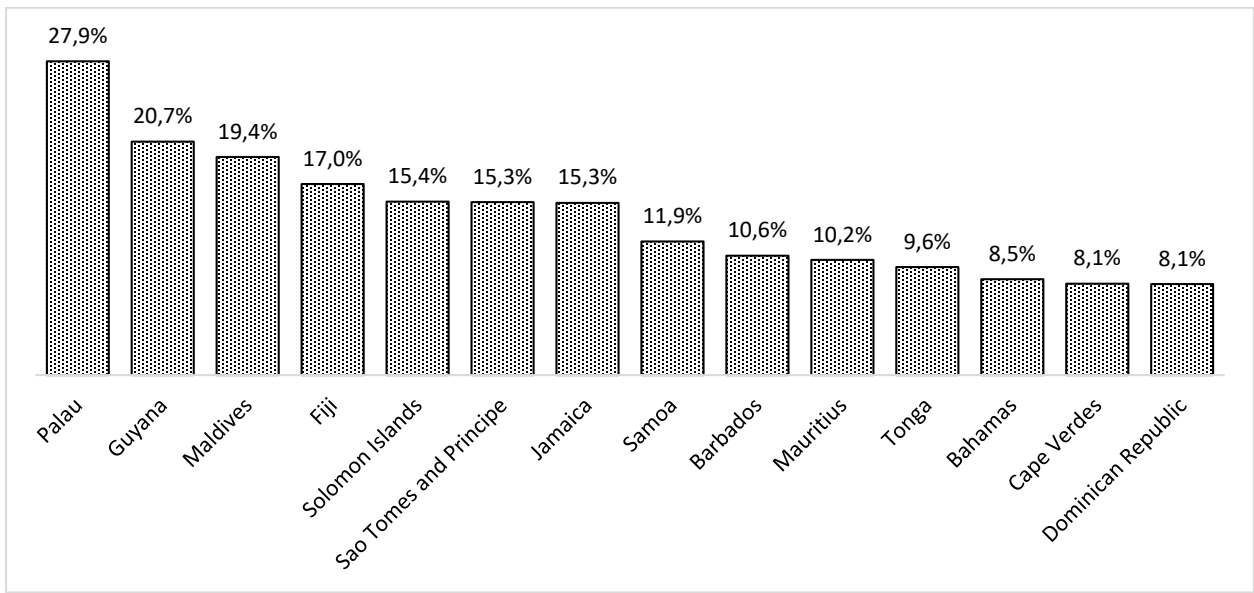
192 was 20.2%, Seychelles, 14.8%, Maldives, 10.1% and Belize, 6.9% as compared to Switzerland,

193 1.0%, Mali, 0.8% and Uganda, 2.0%. Oil price hikes give rise to inflation, trade deficits and high

194 import bills. To counteract the impact of rising oil prices, SIDS have to seek aid through foreign

195 direct investments, grants or by borrowing from other countries. On a household level, a rise in  
 196 energy price causes inflation which can surcharge family budget and disproportionately affect  
 197 those who show little resilience to cope with price fluctuations. Businesses might be less  
 198 competitive as they have to raise input costs and unlikely to increase final prices. Therefore, export  
 199 decreases which can dis-equilibrate balance of payments. Declining economic growth can  
 200 pressurise government to inject funds for fuel subsidisation. For example, in 2008, Marshall  
 201 Islands government has injected \$8 million to the state-owned utility company for continuous oil  
 202 procurement (Davies and Sugden, 2010).

203



204

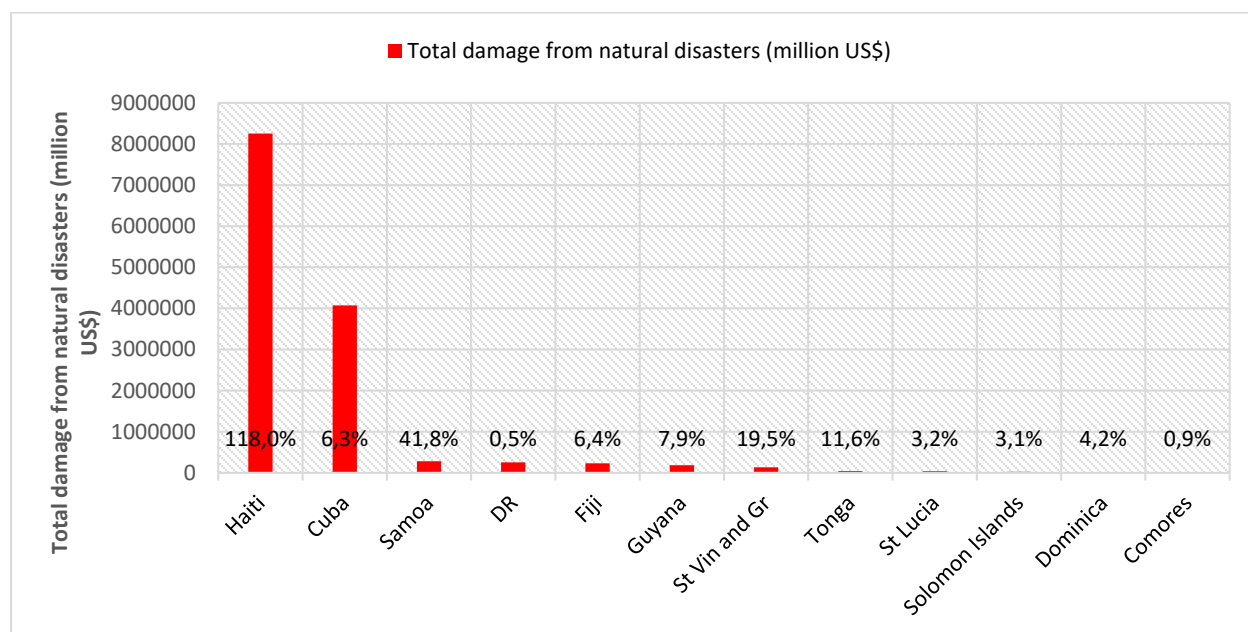
**Fig. 2.** Percentage share of GDP on oil imports for selected SIDS, 2013 (Source: World Development Indicators, World Bank; authors' calculations)

206

207  
 208 *4.3 Climate change and resilience*

209 Resilience is the ability to make extra preparations and to adapt to changing environment so as to  
 210 resist and address disruptions at the earliest (President Policy Directive 21, 2013) and our experts  
 211 aim address the disastrous effects of climate change on island nations and their inability to mitigate  
 212 and adapt to them. An energy system cannot be sustainable if it causes environmental externalities  
 213 such as overexploitation of natural resources, air pollution and contribute to the negative  
 214 consequences of climate change. Climate change is known to destabilise naturally-occurring  
 215 cycles and to be an initiator of more frequent and severe natural calamities such as droughts, floods,

216 tropical cyclones and tsunamis. Cyclones are formed by the interaction of the atmosphere and sea  
 217 and are quite impactful for islands causing massive destruction of infrastructure, communication  
 218 services and settlements. (UNEP, 2014). The damage caused by natural disasters can even surpass  
 219 a country's GDP resulting in major economic set-back (Fig. 3). In Haiti, for example, total costs  
 220 of damage from natural disasters from 2000–2014 were 118.0% of its GDP (high because of  
 221 January 2010 earthquake), in Samoa total costs amounted to 41.8% of its GDP as shown in Fig 3.  
 222 and in Dominican Republic (DR) total damage was about 0.5% of its GDP. In SIDS, experts take  
 223 climate change as a subset of energy security. Past authors have synergised climate change, energy  
 224 access, renewable energy and air pollution with energy security policies for many countries  
 225 (Bazilian et al., 2011; Bang, 2010; Bollen et al., 2010; King and Gullede, 2016; Rogers–Hayden  
 226 et al., 2011; Shadman et al., 2016; van Vliet et al., 2012) which highlight the need to implement  
 227 climate change mitigations measures to build resilience and maintain energy security.  
 228



229  
 230 **Fig. 3.** Cumulative total cost of damages from natural disasters for the period 2000–2014 in  
 231 some selected SIDS and the percentage share of GDP it accounts for (Sources: World  
 232 Development Indicators, World Bank; International Disaster Database; authors' calculations)  
 233

234 For SIDS, being resilient to disruptions does not only mean disruptions from changing  
 235 environmental conditions. It is a risk management approach (Roegel et al., 2014) that does not

236 only include withstanding climatic conditions, but other shocks like terrorism, accidents, sabotage,  
237 theft and import supply risks, too (Yeeles and Akporiaye, 2016). As put forward in Goldthau and  
238 Sovacool (2012), energy systems fall short of resilience that can be detrimental to external shocks  
239 and this is an issue in SIDS as potential approaches to enforce resilience are still unimplemented.  
240 A typical example is the threat of attacks from Somalian pirates to oil tankers destined to countries  
241 in the Indian Ocean where there is still room for improvement though some measures have been  
242 taken.

243

#### 244 *4.4 Governance*

245 The role of governmental authorities of oil importing countries is critical to devise and coordinate  
246 policies around energy and sustainability issues (Fudge et al., 2016). Sound and forward-looking  
247 government can establish energy policies to mitigate short-term oil disruptions and build tough  
248 and robust infrastructure to maintain long-term energy supply (Ang et al., 2015). Most of the  
249 government in SIDS provide subsidy to dampen oil prices and thus, make energy costs affordable  
250 to islanders. The example of the Marshall Islands given above, where the government injected \$8  
251 million, best illustrates such effort from their government. Other examples include Samoa where  
252 the government has reduced tax rates on petroleum products to lessen the burden on consumers  
253 (Davies and Sugden, 2010). Indeed, fuel subsidisation can increase government expenditures on  
254 the national budget, and this is why good governance is required to efficiently balance revenues  
255 and expenditures in the national budget. For oil importers, government authorities have to plan  
256 and intervene promptly to reduce impacts of energy security.

257

#### 258 *4.5 Energy Infrastructure*

259 It was found that the fifth aspect of energy security was energy infrastructure. Energy  
260 infrastructure refers to all components of the energy supply chain, which in the case of SIDS refers  
261 to transport by sea, disembarkment of oil, conversion to secondary sources (electricity) and its  
262 transmission and distribution or supply of primary energy sources. Hence, energy infrastructure  
263 for oil importing countries include high efficiency refineries, proper oil tankers, adequate berthing  
264 and ports and oil tanks for oil storage. In this respect, ports need to be equipped with proper  
265 berthing lengths, quay apron areas and road access. Regular maintenance has to be done to ensure  
266 that port infrastructure provide the intended function. In addition, maritime accidents occurring

267 from either sinking ships, collisions of ships or collision with port infrastructure can narrow  
268 approach channels and obstruct anchorages and port areas in some SIDS (UNCTAD, 2014). Since  
269 most SIDS have only one berth, damage to it can hinder imports and exports of goods. This is a  
270 direct threat to a country's energy security as infrastructure is the key component of the oil supply  
271 chain. Poor maintenance and inadequate financial and technical resources can cause accidents like  
272 oil spills. The Asian Development Bank (2007) provides some serious issues with port  
273 infrastructure in the Pacific countries and among, highlights that Palau port, which dates back to  
274 World War II need to be overhauled for continuous operation. Oil storage tanks have to be robust  
275 enough to resist natural disasters.

276 Efficient infrastructure is also vital to maintain security of electricity supply. Less efficient cables  
277 and transformers and other equipment for electricity transmission and distribution is mandatory  
278 for adequate electricity distribution. In Haiti for instance, 60% of electricity supplied on the grid  
279 is lost in terms of transmission and distribution losses (World Bank, 2014) which entail high  
280 economic consequences for the country. Though these losses cannot be completely eliminated,  
281 they can be minimized by regular maintenance, improvement in power factor among other  
282 measures. Besides, the March 2011 nuclear catastrophe in Japan and the subsequent huge trade  
283 deficits the disaster created for the country (Vivoda, 2012) directly indicate the need for proper  
284 planning of electricity generating infrastructure to withstand disasters of any magnitude.

285

#### 286 *4.6 Equity*

287 An energy system cannot be regarded as secure if there exist within the system an unequal  
288 distribution of energy where some areas have access to energy while others do not. The relation  
289 between equity and energy security can be discussed in two ways – firstly, in terms of oil supply  
290 and with respect to the supply secondary energy sources (electricity). The first way lies in the  
291 unequal distribution of oil among energy importers and exporters. Thus, Asian–Pacific, European  
292 and North–American countries consume 80% of the world oil but control 10% of the world's oil  
293 reserves. Former Soviet Union, Africa, Latin America and countries making the Middle East  
294 control 90% of the global oil reserves but consume 20% of the global oil (BP, 2008 cited in Vivoda,  
295 2009). The global energy market is therefore, quite unbalanced. On the other side, the sheer size  
296 and pace of growth of China and India is changing the global energy market with an ever-  
297 increasing appetite for oil (Vivoda, 2010). Under these circumstances, for holding more of this

298 finite volume of oil, China has planned energy strategies such as import diversification (Wu, 2014)  
299 which can efficiently hog more oil resulting in greater competition for oil on the market. Experts  
300 discussed that even though equity is difficult to quantify, within such fierce competition, SIDS fall  
301 far behind and are often ignored due to their relatively small oil consumption and inability to offer  
302 competitive prices. In simple terms, SIDS are neither competitive nor powerful enough to compete  
303 with superpowers for oil to which SIDS are highly dependent on.

304 Secondly, domestic supply of energy in terms of electricity is rarely viewed as equitable as some  
305 regions have a reliable supply of electricity while in other regions, especially in villages and rural  
306 areas access to electricity is basically low. In the PICs for instance, electrification rate (amount of  
307 population having access to electricity) varies from 14% in Solomon Islands and 17% in Vanuatu  
308 as compared to 89% in Fiji to 99% in Samoa (Dornan, 2014). The inability to supply equitable  
309 access to energy results in poverty aggravation and the deepening of the rich–poor gap in  
310 developing countries.

#### 311 *4.7 Energy efficiency*

312 Energy security and efficiency is closely linked as reported by the World Bank (2005) and ESCAP  
313 (2008). By opting for more efficient energy technologies, the overall energy demand (whether in  
314 terms of oil or electricity) of a particular region can be reduced, thus alleviating the pressure on  
315 governmental authorities to supply more energy. Government will therefore have more funds to  
316 inject in other priority areas for better development of the country. Energy efficiency is an  
317 effective tool to mitigate global emissions and to tackle oil security problems in cases of oil price  
318 hikes. It is a cost–effective strategy to mitigate risks of energy security in islands (Raghoo et al.,  
319 2017).

320

### 321 **5 Potential strategies for improving energy security in SIDS**

322 An account of different practical initiatives that can be adopted to enhance security of energy  
323 supply in oil importing SIDS is given here. Before any initiative or policy is passed, a  
324 comprehensive feasibility study must be conducted to identify flaws and benefits in the proposed  
325 strategy. The applicability of each strategy in the context of SIDS is beyond the scope of this  
326 paper. It only presents some potential ways for energy security improvement in islands.

327

#### 328 *5.1 Demand Side Management (DSM) and Energy Efficiency*

329 Previously pointed out by Narula and Reddy (2016), the intensive focus on ‘security of energy  
330 supply’ leads to confusion of the role of demand side management and energy efficiency in  
331 enhancing energy security. DSM consists of a set of activities that monitors and alters end–users’  
332 energy demand. It is achieved by efficiency improvements on the customer’s side and ultimately  
333 results in an overall reduction of fossil fuels consumption. Benefits of DSM practices and relevant  
334 management techniques are thoroughly discussed in Strbac (2008). For SIDS, DSM is the least  
335 costly option to reduce dependency on oil imports.

336 Energy efficient measures can be adopted in industries, transport and buildings. For industries that  
337 rely on oil to power equipment, proper housekeeping, regular maintenance, industrial energy audits  
338 and using more efficient machinery in the plant can decrease fuel input. Energy efficiency in  
339 buildings can be achieved by applying efficient techniques (such as passive solar technologies) in  
340 the construction phase of buildings. Simple household measures such as proper tuning of air  
341 conditioners, switching off electrical appliances when not in use or using more efficient lamps for  
342 lighting can enormously help in cutting–off electricity bill and in the foremost, oil consumption in  
343 a region and eventually releases of greenhouse gases. In the transportation sector, which is the  
344 most oil consuming sector, proper road planning such as street layouts, pavements improvements  
345 and other infrastructural measures can help to reduce oil intake in vehicles. Using hybrid cars,  
346 prioritising walking and cycling for short distances, reducing travel speed for vehicles and mass  
347 transport are also good initiatives to curb oil intake (Sathaye et al., 2007). As simple as it may  
348 seem, some energy efficient practices require little or no cost at all. It is the coalition of these  
349 million individual small actions by islanders that can reduce dependency on imported fossil fuels.  
350 As an example of energy efficiency initiative, the proposed Sea Water Air Conditioning Project  
351 (SWAC) in Mauritius to use seawater pumped from the ocean to replace air conditioning in  
352 buildings in the capital city is a major project expected to replace the equivalent of 30 MW  
353 electrical power by an ocean derived cooling system (REN21, 2015). With regards to the different  
354 energy efficiency measures and policies available (see IEA, 2015), it is essential to implement an  
355 action plan based on funds available, environment, demography and other territorial data to assess  
356 which measure or policy is best–suited for which region (Sanseverino et al., 2014).

357

358 *5.2 Strategic Petroleum Reserves (SPR)*

359 SPR or stockpiling is the storage of petroleum to be used during short-term oil supply disruptions  
360 or in emergency situations such as in the occurrence of natural catastrophes. SPR is not a recent  
361 approach to tackle oil security problems (for e.g., see Balas, 1979) but since most academic  
362 literature is focussed on the United States, China or in IEA member countries, SPR probable  
363 application within SIDS has remained understudied. While setting up of an SPR in small islands  
364 can be subjected to many debates due to numerous factors to be considered, such as optimal size  
365 of the reserve, financial and institutional issues, drawdown decision; it nevertheless represents a  
366 good mean to plan for anticipated oil scarcity. Benefits of having SPR are purely economic. First,  
367 there are opportunities that exist where government can buy oil at a lower price and sell it to  
368 customers at a higher price. Secondly, SPR can dampen oil price hikes during disruptions thereby  
369 limiting economic setback and panic buying. This gives economies enough time to find alternative  
370 solutions to alleviate oil supply shortages (Paik et al., 1999) and also provide with a short-term  
371 solution to tackle oil price spikes issues. In the exceptional case of SIDS, frequent natural  
372 catastrophes can paralyse port activities or make it difficult for ships to deliver oil. In these cases,  
373 reserves from the SPR can be drawn to satisfy energy needs rather than attempting to disembark  
374 oil from ships under poor meteorological conditions. Finally, it can alleviate politically or  
375 economically motivated oil disruptions (Taylor and van Doren, 2005). Paik et al. (1999) discussed  
376 the available technologies for oil storage and their cost implications. Other authors (Meng et al.,  
377 2016; Zhou et al., 2016; Zhu et al., 2012) have focussed on optimal sizing of oil reserves by  
378 stochastic modelling.

379 Leiby et al. (2002) argued that the cost that small economies have to bear to set up oil stockpiles  
380 do not justify the relevant benefits accrued. However, benefits derived from stockpiling are  
381 additive and thus, a reserve can be jointly shared by a collection of nearby islands especially, in  
382 the Caribbean and Pacific regions. In addition, stockpiling oil can thus be used as a tool for  
383 diplomacy.

384

### 385 *5.3 Energy mix diversification*

386 SIDS are blessed with a huge renewable energy potential whose exploitation and development are  
387 highly encouraged to diversify energy mix and to reduce dependency on oil imports. Much efforts  
388 have already been done to expand sustainable sources of energy in SIDS. Most of the SIDS have  
389 established RE goals by a certain time period (except Papua New Guinea) (Dornan, 2014).



390 Mauritius for instance, has come up with a long-term energy strategic plan and is expected to  
 391 generate 8% electricity by wind, 6% by hydro, 2% by solar PV and 2% by geothermal energy by  
 392 2025 from existing 3% hydro and 0.2% solar with limited work geothermal energy so far (CSO,  
 393 2015; MEPU, 2009; Surroop and Raghoo, 2017; Wolf et al., 2017). A wind farm has recently  
 394 started but there is still a long way to go to achieve targets. Table 3 demonstrates the RE potential  
 395 for some Caribbean SIDS, as an example.

396

397 **Table 3.** Renewable energy potential in Caribbean SIDS (Source: Nextant, 2010)

Caribbean islands	Wind (MW)	Geothermal (MW)	Hydro (MW)	Solar PV (MW)
Antigua and Barbuda	400	-	-	27
Barbados	10	-	-	26
Dominica	-	100	8	45
Dominican Republic	3200	-	210	2899
Grenada	11	499	-	21
Haiti	10	-	50	1654
Jamaica	70	-	22	650
St Kitts and Nevis	5	300	-	16

398

399 There is no debate on the fact that SIDS are blessed with abundant RE sources (Shirley and  
 400 Kammen, 2013; Timilsina and Shah, 2016; Prasad et al., 2017). Arguably, solar, wind, biomass  
 401 and hydroelectricity seem the most preferred RE sources notably because of the current mature  
 402 status of their technologies and the cost-competitiveness with fossil fuel technologies. However,  
 403 there are some financial and institutional barriers that small islands face to achieve RE targets.  
 404 Although SIDS receive some financial aid (known as Official Development Assistance, ODA)  
 405 (Niles and Lloyd, 2013), governments are unable to invest in the energy sector as they have to  
 406 improve other sectors such as education, water, food security and poverty alleviation. Timilsina  
 407 and Shah (2016) comprehensively described the barriers and ‘policy enablers’ for more renewable  
 408 energy development in SIDS. It is also very difficult to access finance from foreign investment  
 409 due to significant development challenges (Dornan, 2015) such as lack of incentives for private  
 410 sector participation, diseconomies of scale and a thin financial base. However, as demonstrated

411 by Dornan and Jotzo (2015), who applied the portfolio theory in SIDS, found that energy efficiency  
412 measures combined with renewable technologies help in reducing the cost of production which in  
413 turn reduces the financial risk. This is in contrary with other countries where there exists a cost–  
414 risk trade–off for RE integration. Ultimately, to drive more RE within SIDS, it is important to  
415 establish incentives to allow elements of an economy (private sector, for instance) to participate  
416 and invest in more sustainable sources. An example is the Turtle Beach Resort in Barbados where  
417 French Polynesian government gave a 35% tax credit to substitute electric water heating powered  
418 by diesel generators by solar water heating hence yielding \$1.48 million in energy savings and 655  
419 tons of carbon emissions avoided from 1997 to 2013 (IRENA, 2014). Another policy instrument  
420 is feed–in tariff (FIT) which guarantees investors a fixed price for electricity generated from green  
421 sources for them to attain a reasonable return on investment (Jacobs et al., 2013). Gaps in technical  
422 and educational skills of islanders to handle renewable energy technologies can be addressed by  
423 training and capacity building.

424

## 425 **6 Conclusion**

426 Energy security is fundamental for the sustainable socio-economic development of SIDS. Since  
427 SIDS are not energy self–sufficiency and rely mostly on fossil fuels for meeting their energy needs,  
428 the security of energy supplies is of utmost importance. In this article, an attempt has been made  
429 to identify potential determinants of energy security for Small Island Developing States. The seven  
430 dimensions identified are regarded key to ensuring a more secure energy supply in SIDS. Hence,  
431 it is suggested that, based on the conceptual framework presented in this paper, more research  
432 work is needed to develop energy security indicators and indices in SIDS. Dimensions proposed  
433 coupled with the special vulnerabilities faced by islands, can be considered to gauge energy  
434 security performance and, thus, improve planning for future energy policies. It can also be  
435 observed that most strategies to enhance energy security are either underexploited or understudied,  
436 indicating further research opportunities. Energy efficiency, being a key to improve energy  
437 security is either misunderstood or ignored by policymakers so more awareness raising and  
438 communicating the advantages of efficient use and production of energy is needed for small island  
439 nations.

440

## 441 **Acknowledgments**

442 This paper was produced in line with the EDULINK/European Union (EU) funded project L<sup>3</sup>EAP.  
443 The arguments pointed out in this paper belong entirely to the authors and cannot, under any  
444 circumstances be taken as the opinions of the European Union. The authors of this article are also  
445 grateful to the anonymous reviewers who have significant contributed to improve the quality of  
446 this paper.

447

#### 448 **References**

- 449 ADB, 2007. REG: Improving the Delivery of infrastructure services in the Pacific, Technical  
450 Assistance Consultant's Report, Project Number 38633, December 2007. Asian Development  
451 Bank. <http://www.adb.org/sites/default/files/project-document/65495/38633-reg-tacr.pdf>  
452 [accessed on June, 18 2016]
- 453 Ang, B.W., Choong, W.L., Ng, T.S., 2015. Energy security: Definitions, dimensions and indexes.  
454 Renewable and Sustainable Energy Reviews, 42. 1077–93
- 455 APERC, 2007. A quest for energy security in the 21<sup>st</sup> century. Asian Pacific Energy Research  
456 Centre, Tokyo, Japan
- 457 Asif, M., Muneer, T., 2007. Energy supply, its demand and security issues for developed and  
458 emerging economies. Renewable and Sustainable Energy Reviews, 11, 1388–1413
- 459 Bacon R., Kojima, M., 2008. Vulnerability to Oil Prices Increases: A decomposition analysis of  
460 161 countries. Extractive Series and Development Industries 1. World Bank
- 461 Balas, E., 1979. The Strategic Petroleum Reserve: how large should it be? Carnegie-Mellon  
462 University, Design Research Center. Pittsburgh
- 463 Bang, G., 2010. Energy security and climate change concerns: Triggers for energy policy change  
464 in the United States?. Energy Policy, 38, 1645–1653
- 465 Bazilian, M., Hobbs, B.F., Blyth, W., MacGill, I., Howells, M., 2011. Interactions between  
466 energy security and climate change: A focus on developing countries. Energy Policy, 39, 3750–  
467 3756
- 468 Blancard, S., Hoarau J.F., 2013. A new sustainable human development indicator for small island  
469 developing states: A reappraisal from data envelopment analysis. Economic Modelling, 30, 623–  
470 635

471 Blumer, Y.B., Moser, C., Patt, A., Seidl, R., 2015. The precarious consensus on the importance  
472 of energy security: Contrasting views between Swiss energy users and experts. *Renewable and*  
473 *Sustainable Energy Reviews*, 52, 927–936

474 Bollen J., Hers, S., van der Zwaan, B., 2010. An integrated assessment of climate change, air  
475 pollution, and energy security policy. *Energy Policy*, 38, 4021–4030

476 Briguglio, I., 1995. Small Islands Developing States and the economic vulnerabilities. *World*  
477 *Development*, 23(9), 1615–1632

478 Cao, W., Bluth, C., 2012. Challenges and countermeasures of China’s energy security. *Energy*  
479 *Policy* 53, 581–383

480 Cherp, A., Jewell, J., 2011. The three perspectives of energy security: intellectual history,  
481 disciplinary roots and the potential for integration. *Current Opinion in Environmental*  
482 *Sustainability*, 3, 202–212

483 Chester, L., 2010. Conceptualising energy security and making explicit its polysemic nature.  
484 *Energy Policy*, 38, 887–895

485 Chuang, M.C., Ma, H.W., 2013. An assessment of Taiwan’s energy policy using multi-  
486 dimensional energy security indicators. *Renewable and Sustainable Energy Reviews*, 17, 301–  
487 311

488 CRED (Centre for Research on the Epidemiology of Disasters). Available on  
489 <http://www.emdat.be/database> (accessed on 15/09/16)

490 CSO, 2015. Digest of Energy and Water  
491 Statistics, 2014. Central Statistics Office, Mauritius

491 Davies, M., Sugden, C., 2010. Microeconomic impacts of energy prices in the Pacific. *Pacific*  
492 *Financial Technical Assistance Centre Regional Papers*, Suva, Fiji

493 Dornan, M., 2014. Access to electricity in Small Island Developing States of the Pacific: Issues  
494 and Challenges. *Renewable and Sustainable Energy Reviews*, 31, 726–735

495 Dornan, M., 2015. Renewable Energy Development in Small Island Developing states of the  
496 Pacific. *Resources*, 4, 490–506

497 Dornan, M., Jotzo, F., 2015. Renewable technologies and risk mitigation in small island  
498 developing states: Fiji’s electricity sector. *Renewable and Sustainable Energy Reviews*, 48, 35–  
499 48

500 Ebinger, C.K., 2011. The meaning of energy security depends on who you are, retrieved on  
501 February 01, 2016, [http://www.brookings.edu/research/opinions/2011/10/10-energy-security-](http://www.brookings.edu/research/opinions/2011/10/10-energy-security-ebinger)  
502 [ebinger](http://www.brookings.edu/research/opinions/2011/10/10-energy-security-ebinger)

503 ESCAP, 2008. Energy security and sustainable development in Asia and the Pacific. United  
504 Nations Economic and Social Commission for Asia Pacific, Bangkok

505 Fudge, S., Peters, M., Woodman, B., 2016. Local authorities as niche actors: the case of energy  
506 governance in the UK. *Environmental Innovation and Societal Transitions*, 18, 1–17

507 Goldthau, A., Sovacool, B.K., 2012. The uniqueness of the energy security, justice and  
508 governance problem. *Energy Policy*, 41, 232–240

509 Gupta, E., 2008. Oil–vulnerability index of oil–importing countries. *Energy Policy*, 3, 1195–1211

510 Hughes, L., 2012. A generic framework for the description and analysis of energy security in an  
511 energy system. *Energy Policy*, 42, 221–231

512 IEA, 2015. Regional Energy Efficiency Policy Recommendations – Latin America and the  
513 Caribbean. International Energy Agency, Paris

514 IRENA, 2012. Renewable Energy Technologies: Cost Analysis Series – Vol. 1: Power Sector,  
515 Issue 1/5. Biomass for Power Generation. International Renewable Energy Agency, Bonn,  
516 Germany.

517 IRENA, 2014. Renewable Energy Opportunities for Islands Tourism. International Renewable  
518 Energy Agency, Bonn, Germany

519 Jacobs D., Marzolf, N., Paredes, J.P., Flynn H., Becker–Brick, Solano–Peralta, M., Rickerson, W.,  
520 2013. Analysis of renewable energy incentives in the Latin America and Caribbean region: The  
521 feed–in tariff case. *Energy Policy*, 60, 601–610

522 King M.D., Gullede, J., 2013. The climate change and energy security nexus. *The Fletcher*  
523 *Forum of World Affairs*, 37(2); 25–44

524 Kucharski J., Unesaki H., 2015. A policy–oriented approach to energy security. *Procedia*  
525 *Environmental Sciences*, 28, 27–36

526 Leal Filho, W., Voudouris, V. (Eds.) (2013) *Global Energy Policy and Security*. Springer, London

527 Leal Filho, W. (2015) World energy outlook emphasises the need for low-carbon energy  
528 developments. *International Journal of Climate Change Strategies and Management*, 7 (4), 2-3

529 Lefèvre, N., (2010). Measuring the energy supply implications of fossil fuel resource  
530 concentration. *Energy Policy*, 38, 1635–1644

531 Leiby, P.N., Bowman, D., Jones, D.W., 2002. Improving Energy Security through an international  
532 cooperative approach to emergency oil stockpiling. Proceedings of the 25<sup>th</sup> Annual IAEE  
533 International Conference, June 26–29, Aberdeen, Scotland

534 Löschel, A., Moslener, U., Rubbelke D.T.G., 2010. Indicators of energy security in industrialised  
535 countries. *Energy Policy*, 38, 1665–71

536 Martchamadol, J., Kumar, S., 2013. An aggregated energy security performance indicator.  
537 *Applied Energy*, 103, 653–670

538 Meng, F.Y., Zhou, P., Bai, Y., Zhiu, D.Q., Ju., K.Y., 2016. Desirable policies of a strategic  
539 petroleum server I coping with disruption risk: A Markov decision process approach. *Computers  
540 and Operations Research*, 66, 58–66

541 MEPU, 2009. Long Term Energy Strategy 2009 – 2025. Ministry of Energy and Public Utilities,  
542 Mauritius

543 Miles, M.B., Huberman A.M., 1994. *Qualitative data analysis: a sourcebook of new methods* (2<sup>nd</sup>  
544 Edition). Thousand Oaks, CA, Sage Publications, Inc. USA

545 Misila, p., Winyuchakrit, P., Lemmeechokchai, B., 2015. Roadmap to Thailand’s Nationally  
546 Appropriate Mitigation (NAMAs) by 2020: Energy Security and Co–Benefit Aspects. *Energy  
547 Procedia*, 79, 590–595

548 Narula K., Reddy, S.B., 2015. Three blind men and an elephant: The case of energy indices to  
549 measure energy security and energy sustainability. *Energy*, 80, 148–158

550 Narula K., Reddy, S.B., 2016. A SES (sustainable energy security) index for developing countries.  
551 *Energy*, 94, 326–343

552 Nexant, 2010. Caribbean Regional Electricity Generation, Interconnection and fuels supply  
553 strategy, final report,  
554 [www.caricom.org/jsp/community\\_organs/energy\\_programme/electricity\\_gifs\\_strategy\\_final\\_re  
555 port.pdf](http://www.caricom.org/jsp/community_organs/energy_programme/electricity_gifs_strategy_final_report.pdf) (accessed March, 08 2016)

556 Niles, K., Lloyd, B., 2013. Small Island developing states (SIDS) & energy aid: impacts on the  
557 energy sector in the Caribbean and Pacific. *Energy for sustainable Development*, 17, 521–530

558 Paik I., Leiby, P., Jones, D., Yokobori, K., Bowman, D., 1999. Strategic Oil stocks in the APEC  
559 region. Proceedings of the 22<sup>nd</sup> IAEE Annual International Conference, International Association  
560 for Energy Economists, Italy

561 Patton, M.Q., 2002. *Qualitative evaluation and research method* (3<sup>rd</sup> Edition). Thousand Oaks,  
562 Sage Publications, Inc. USA

563 Phdungsilp, A., 2015. Assessing Energy security performance in Thailand under Different  
564 scenarios and Policy Implication. *Energy Procedia*, 79, 982–87

565 Prasad RD, Bansal RC, Raturi A, 2017. A review of Fiji’s energy situation: Challenges and  
566 strategies as a small island developing state. *Renewable and Sustainable Energy Reviews*, 75,  
567 278–92

568 Presidency Policy Directive 21, 2013. [https://www.whitehouse.gov/the-press-](https://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil)  
569 [office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil,](https://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil)  
570 Accessed on March 3, 2016

571 Raghoo P, Jeetah P, Surroop D, 2017. Lifelong learning (LLL) for energy practitioners in Small  
572 Island Developing States (SIDS): The pivotal role of education in energy efficiency and demand  
573 side management. In: Leal Filho W (ed.), *Climate Change Adaptation in Pacific Countries,*  
574 *Climate Change Management*, Springer

575 Raghoo P, Surroop D, Wolf F, 2017. Natural gas to improve energy security in Small Island  
576 Developing Countries: A techno-economic analysis. *Development Engineering*, 2, 92–98

577 REN21, 2015. *SADC Renewable Energy and Energy Efficiency: Status Report*. Paris, REN21  
578 Secretariat

579 Rentschler, J.E., 2013. Oil price volatility, economic growth and the hedging role of renewable  
580 energies. *Policy Research Working Paper 6603*, World Bank, Washington DC

581 Roege P.E., Collier, Z.A., Mancillas, J., McDonagh, J.A., Linkov, I., 2014. Metrics for energy  
582 resilience. *Energy Policy*, 2014, 249–56

583 Rogers–Hayden, T., Lorenzoni I., Hatton, F., 2011.  
584 ‘Energy security’ and ‘climate change’: Constructing UK energy discursive realities. *Global*  
585 *Environmental Change*, 21, 134–42

586 Rosen, M. A., 2009. Key energy-related steps in addressing climate change. *International Journal*  
587 *of Climate Change Strategies and Management*, 1, 31–41

588 Sanseverino, E.R., Sanseverino R.R., Favuzza, S., Vaccaro, V., 2014. Near zero energy islands in  
589 the Mediterranean: Supporting policies and local obstacles. *Energy Policy*, 66, 592–602

590 Sathaye, J.A, Cocklin, C., Heller, T., Lecocq, F., Llanes–Regueiro J., Pan, J., Petschel–Held G., Robinson,  
591 J., Rayner, S., Schaeffer, R., Sokona, Y., Swart, R., Winkler, H., 2007. Sustainable Development  
and Mitigation. In *Climate Change 2007: Mitigation*. Contribution of Working Group III to the

592 Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R.  
593 Davidson, P.R Bosch, L.A. Meyer (eds)], Cambridge University Press, UK, NY

594 Selvakkumaran, S., Limmeechokchai, B., 2013. Energy security and co-benefits of energy  
595 efficiency improvements in three Asian countries. *Renewable and Sustainable Energy Reviews*,  
596 20, 491–503

597 Shadman, F., Sadeghipour, S., Moghavvemi, M., Saidur, R., 2016. Drought and energy security  
598 in key ASEAN countries. *Renewable and Sustainable Energy Reviews*, 53. 50–58

599 Shirley R, Kammen D, 2013. Renewable energy sector development in the Caribbean: Current  
600 trends and lessons om history. *Energy Policy*, 57, 244–52

601 Sovacool B.K., Mukherjee I., 2011. Conceptualizing and measuring energy security: A  
602 synthesized approach. *Energy*, 36, 5343–55

603 Sovacool, B.K., 2011. Evaluating energy security in the Asia Pacific: Towards a more  
604 comprehensive approach. *Energy Policy*, 39, 7472–79

605 Strbac, G., 2008. Demand Side Management: Benefits and Challenges. *Energy Policy*, 36, 4419–  
606 26

607 Stringer, K.D., 2008. Energy Security: applying a portfolio approach. *Baltic Security and Defense*  
608 *Review*, 10, 121–42

609 Surroop, D., Raghoo, P., 2017. Energy Landscape on Mauritius. *Renewable and Sustainable*  
610 *Energy Reviews*, 73: 688–94

611 Taylor, J., van Doren, P., 2005. The Case against Strategic Petroleum Reserve. *Policy Analysis*,  
612 No. 555, Cato Institute

613 Timilsina, G.R., Shah, K.U., 2016. Filling the gaps: Policy supports and interventions for scaling  
614 up renewable energy development in Small Island Developing States. *Energy Policy*, 98, 653–62

615 UNCTAD, 2014. Closing the distance: Partnerships for sustainable and resilient transport systems  
616 in SIDS. United Nations Conference on Trade and Development, Geneva

617 UNEP, 2014. Global Environment Outlook, Small Island Developing States. United Nations  
618 Environmental Programme, Nairobi, Kenya

619 van Vliet, O., Krey, V., McCollum, D., Pachauri, S., Nagai, Y., Rao, S., Riahi, K., 2012. Synergies  
620 in the Asian energy system: Climate change, energy security, energy access and air pollution.  
621 *Energy Economics*, 34, 5470–80



622 Vivoda, V., 2009. Diversification of oil imports sources and energy security: A key strategy or an  
623 elusive objective? *Energy Policy*, 37, 4615–23

624 Vivoda, V., 2010. Evaluating energy security in the Asia–Pacific region. A novel methodological  
625 approach. *Energy Policy*, 38, 5258–63

626 Vivoda, V., 2012. Japan’s energy security predicament post–Fukushima, *Energy Policy*, 46, 135–  
627 143

628 von Hippel, D., Suzuki, T., Williams, J.H., Savage T., Hayes, P., 2011. Energy security and  
629 sustainability in Northeast Asia. *Energy Policy*, 39, 6719–30 Winzer, C., 2012. Conceptualizing  
630 energy security. *Energy Policy*, 46, 36–48

631 Wolf, F., Surroop, D, Singh, A., Leal F., 2016. Energy access and security strategies in Small  
632 Island Developing States. *Energy Policy*, 98, 663–73

633 World Bank, 2005. *Energy Security issues*. The World Bank Group, Moscow – Washington DC

634 World Bank, 2017. *World Development Indicators – The Little Green Data Book*. Washington  
635 DC.

636 World Development Indicators, 2013. Available on <http://data.worldbank.org/indicator>. World  
637 Bank (accessed on 15/09/16)

638 World Development Indicators, 2014. Available on <http://data.worldbank.org/indicator>. World  
639 Bank (accessed on 17/12/17)

640 World Energy Council, 2017. *World Energy Trilemma Index 2017 – Monitoring Sustainability of*  
641 *National Energy Systems*, UK

642 Wu, K., 2014. China’s energy security: Oil and gas. *Energy Policy*, 73, 4–11

643 Yeeles, A., Akporiaye, A., 2016. Risk and resilience in the Nigerian oil sector: The economic  
644 effects of pipeline sabotage and theft. *Energy Policy*, 88, 187–96

645 Zhou, P., Bai, Y., Meng, F., Tian, L., 2016. Desirable strategic petroleum reserves policies in  
646 response to supply uncertainty: A stochastic analysis. *Applied Energy*, 162, 1523–29

647 Zhu, Z., Liu, L., Wang, J., 2012. Optimization of China’s strategic petroleum reserve policy: A  
648 Markovian decision approach. *Computers & Industrial Engineering*, 63, 626–33