



Research Paper

Long-term energy demand modeling and optimal evaluation of solutions to renewable energy deployment barriers in Benin: A LEAP-MCDM approach

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ABSTRACT

Approximately 60 % of Beninese lack access to electricity, relying heavily on traditional energy sources, electricity imports, and low renewable energy integration. This study aims to forecast the energy demand for Benin while reducing greenhouse gas (GHG) emissions and propose alternative solutions to clean energy deployment barriers. The Low Emissions Analysis Platform (LEAP) is used to explore the future energy demand for Benin and associated GHG emissions. Four scenarios have been developed, namely Business as Usual (BAU), High Economic Development (HED), Electrification and Urbanization Growth (EUG), and High Efficient Energy Application (HEEA). In addition, the Fuzzy AHP and TOPSIS techniques have been employed to rank and prioritize alternative solutions to Renewable Energy (RE) deployment barriers in the country. A total of eighteen sub-barriers were identified and classified into five main categories under the four pillars of sustainability (technical, social, economic, and environmental), and nine strategies were identified and proposed to overcome the barriers. The results show that under the BAU scenario, the total energy demand is expected to reach 445 PJ in 2050 from the current demand of around 164 PJ. A total GHG emission of 21 MtCO_{2e} is estimated under the BAU scenario in 2050. However, the HEEA scenario indicates that energy demand would considerably decrease resulting in low GHG emissions from the energy sector. The findings from the Fuzzy AHP ranking show that technical barriers, political and regulatory barriers, and financial and economic barriers, are the top three barriers hindering RE deployment in Benin. Moreover, adequate policy and regulatory framework emerges as the most weighted solution to eliminating barriers to RE deployment in the country. These results encourage the application of effective policy to support sustainable energy transition. The study's approach is applicable to other developing countries outside Benin, offering insights into RE barriers and potential alternative solutions.

List of abbreviations and acronyms: ABERME, Beninese Agency for Rural Electrification and Energy Control; BAU, Business As Usual; CO₂, Carbon dioxide; CSP, Concentrated Solar Power; DGRE, Directorate General Energy Resources; EUG, Electrification and Urbanization Growth; GDP, Gross Domestic Product; GDEX, Gbê-Djigbê Industrial Zone; GHG, Greenhouse Gas; HEEA, High Efficient Energy Application; HED, High Economic Development; HH, Household; IEA, International Energy Agency; IRENA, International Renewable Energy Agency; INSAH, National Institute of Statistics and Economic Analysis; INSTAT, National Institute of Statistics and Demography; LEAP, Low Emission Analysis Platform; LPG, Liquefied Petroleum Gas; MCVDD, Ministry of Living Environment and Sustainable Development; MESSAGE, Model for Energy Supply Strategy Alternatives and their General Environmental Impacts; MtCO_{2e}, Million metric tonnes of CO₂ equivalent; NEMO, Next Energy Modeling System for Optimization; NDC, Nationally Determined Contribution; OPENMODSYS, Open Source Energy Modeling System; PJ, Petajoules; PHODERE, Renewable Energy Development Program; PROVES, Solar Energy Promotion Project; PONADER, National Renewable Development Policy; PANED, National Energy Efficiency Action Plan; PV, Photovoltaic; SSEE, Beninese Company of Electrical Energy; SIMFACTS, Simplified approach to estimating electricity generation's external costs and impacts; SDG7, Sustainable Development Goal 7; SSA, Sub-Saharan Africa; SEB-Benin, Energy Information System of Benin; UNDP, United Nations Development Programme; AHP, Analytic Hierarchy Process; TOPSIS, Technique for Order of Preference by Similarity to Ideal Solution; MCDM, Multi-criteria Decision Making; CC_{0.5}, Closeness Coefficient.

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signals the wires are color coded saudi aramco desktop standards 51 54 engineering

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web arabia to follow the bs en 1089 3 standard of color code for owned cylinders to get a fully harmonized color coding

system mega member companies in the kingdom of saudi arabia will follow a separate color code the colour code outlined in this document applies specifically to gas cylinders for pure gases

engineering encyclopedia - May 15 2023

web saudi aramco desktop standards 7 saes b 067 this standard describes the mandatory safety color coding for equipment and piping in saudi aramco facilities to identify potential hazards and alleviate fire and safety concerns and specifies the following specific paint colors to identify piping and equipment in fire

aramco standards color coding analytics mirowin com - Mar 01 2022

web 4 aramco standards color coding 2020 02 13 enters into force on 1 january 2013 the associated guidelines which assist states and industry in the implementation of marpol annex v have been reviewed and updated and two guidelines were adopted in march 2012 at mepc s sixty third session the 2012 edition of this publication contains the 2012

saudi aramco engineering standard safety identification and safety colors - Aug 18 2023

web requirements 4 1 general 4 1 1 pipes vessels valves and related structural supports shall be painted a neutral background color such as aluminum gray or black which will not detract from the high visibility of the safety colors set out in this specification for coating selection see saes h 001