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The contribution of energy consumption reduction to achieving energy security in Algeria: A case study of Sonelgaz in Boumerdes Province

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***Abstract*---**This study aims to explore methods for reducing energy consumption to achieve energy security in Algeria by decreasing the use of non-renewable energy sources and shifting towards renewable energy, as it is inexhaustible. The research examines the contribution of energy consumption reduction to energy security at Sonelgaz in Blida Province. The study sample included 40 employees, and the findings indicate that the company relies primarily on renewable energy, particularly solar energy, which is abundantly available in Algeria. The study suggests that instead of solely focusing on reducing energy consumption, the company should adopt alternative strategies, such as increasing the use of renewable energy sources, to enhance energy production.

Keywords---Energy security, energy consumption reduction, renewable energy, non-renewable energy.

Introduction

Energy security is a strategic and high-priority issue for policymakers and implementers in every country worldwide. It even extends to the point where energy security is considered part of national security. Algeria is rich in vast energy resources, including both renewable and non-renewable energy sources. Reducing energy consumption is one of the key factors in maintaining energy security in Algeria. This is achieved by decreasing the consumption of non-renewable energy sources and shifting toward renewable energy consumption.

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Based on this premise, the central research problem of this study is formulated as follows:

Main Research Question:
To what extent does reducing energy consumption contribute to achieving energy security at Sonelgaz, Boumerdes branch?
This main question leads to several sub-questions:

Sub-Questions:

- To what extent does reducing non-renewable energy consumption contribute to achieving energy security at Sonelgaz, Boumerdes branch?
- To what extent does shifting towards renewable energy consumption contribute to achieving energy security at Sonelgaz, Boumerdes branch?

To answer the main research question and sub-questions, the following hypotheses are proposed:

Main Hypothesis:
Reducing energy consumption contributes to achieving energy security at Sonelgaz, Boumerdes branch, by decreasing non-renewable energy consumption and shifting toward renewable energy sources.

Sub-Hypotheses:

- Reducing the consumption of non-renewable energy sources (oil, coal, natural gas) contributes to achieving energy security at Sonelgaz, Boumerdes branch.
- Shifting towards renewable energy consumption (solar energy, wind energy, hydropower, geothermal energy) contributes to achieving energy security at Sonelgaz, Boumerdes branch.

Chapter One: Theoretical Framework of the Study

1. Definition of Energy Security
There is no single, universally agreed-upon definition of energy security. However, it can be defined as follows:

- Energy security is *"a state in which a country, along with all or most of its citizens and businesses, has access to sufficient energy sources at affordable prices in the foreseeable future, without facing severe risks of major service disruptions."*
- It is also defined as *"a concept that involves a wide range of relationships between countries and how they interact with one another. It is an integral part of a country's national security strategy."*

Based on these definitions, a narrow perspective of energy security focuses on ensuring energy supply at reasonable prices without disruptions. Meanwhile, a broader perspective considers the ability to guarantee future energy needs through local resources.

2. Energy Transition Strategies
The strategies and steps for energy transition can be summarized in three key measures:

1. **Optimal Energy Consumption:** Achieved through:

- Reducing energy consumption for heating by insulating buildings and improving heating systems.
- Developing multiple transportation methods by selecting sustainable vehicles and adopting new ways to operate them with alternative energy sources, thus reducing the use of energy-derived materials.
- Ensuring electricity savings across all areas of use.

2. **Considering Energy Transition as a Key Driver of Development:** By encouraging economic competition among major energy-producing companies to optimize resource use, integrate renewable energy as an alternative to traditional energy, improve corporate reputation, and create new job opportunities.
3. **Planning the Energy Transition Process:** This involves integrating all energy sector stakeholders within pre-prepared plans and programs aimed at meeting energy demands while preserving the environment and protecting the rights of both current and future generations.

Chapter Two: General Framework of the Field Study

In this chapter, we will examine the tools used in the field study, the total study population, the sample and its characteristics, as well as the statistical processing and interpretation of the obtained results.

1. Study Population and Sample

The study employed a comprehensive survey method, meaning that the study population consists of all employees at Sonelgaz, Boumerdes branch, including both supervisors and subordinates across various departments. Consequently, the study sample is equal to the study population, amounting to 50 individuals**.**
The questionnaires were distributed in accordance with the sample size, and the number of distributed, retrieved, and excluded questionnaires is detailed in the following table:

Table (01): Distributed and Retrieved Questionnaires

Distributed Questionnaires	**Retrieved Questionnaires**	**Excluded Questionnaires**	**Valid Questionnaires for Analysis**
50	47	03	40

Source: Prepared by the researcher based on the questionnaire distribution.

2. Questionnaire Structure

The distributed questionnaire was designed and divided into different sections to collect data, as follows:

- **Section One:** Preliminary data (personal information) related to the respondent.
- **Section Two:** Examines methods of reducing non-renewable energy consumption to achieve energy security at Sonelgaz, Boumerdes branch**,** divided into two dimensions:

- **First Dimension:** Focuses on reducing non-renewable energy consumption, consisting of **nine** items.
- **Second Dimension:** Focuses on customer-related aspects, consisting of twelve items.

3. Statistical Tools Used

The questionnaire data was processed and analyzed using **SPSS V22** software, utilizing the following statistical tools:

- **Percentages and Frequencies:** To determine the frequency of specific variable categories and describe the study sample.
- **Cronbach's Alpha Coefficient:** To ensure the reliability of the measurement scale.
- **Arithmetic Means and Standard Deviations:** To answer the research questions and determine the relative importance of variables.
- **Trend Analysis:** Identified using cell lengths to interpret the computed means.

A **five-point Likert scale** was used to measure respondents' answers to the questionnaire items, as detailed in the following table.

Table (02): Five-Point Likert Scale

Scale	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Weight	01	02	03	04	05
Mean Range	1.00 - 1.79	1.80 - 2.59	2.60 - 3.39	3.40 - 4.19	4.20 - 5.00

Source: Prepared by the researcher based on the questionnaire distribution.

4. Validity and Reliability of the Questionnaire

The validity and reliability of the questionnaire refer to its ability to provide consistent results if redistributed multiple times under the same conditions. In other words, it ensures the stability of responses over time, meaning that the results do not fluctuate significantly when administered to the same sample at different time intervals.

To verify the reliability of the questionnaire, Cronbach's Alpha Coefficient was used as a measure of internal consistency. The calculated **Cronbach's Alpha for the study sample was 86.7%**, which falls within an **acceptable range** for reliability.

Table (03): Cronbach's Alpha Coefficient

Reliability Statistics	**Cronbach's Alpha**	**Number of Items**
Calculated Value	**0.867**	**40**

Source: Prepared by the researcher based on SPSS V22 outputs.

Section Two: Analysis of Demographic Data

1. Distribution of Sample Members by Gender

Table (04): Distribution of Sample Members by Gender

Category	Frequency	Percentage (%)
Male	25	62.5%
Female	15	37.5%
Total	40	100%

Source: Prepared by the researcher based on SPSS V22 outputs.

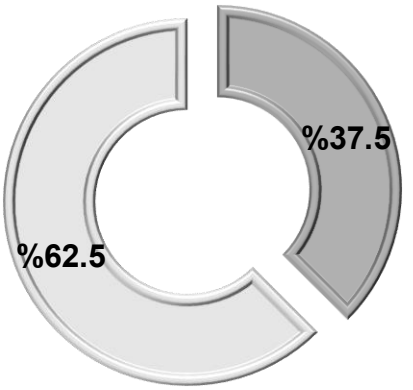

Figure (01): Distribution of Sample Members by Gender Variable
Source: Prepared by the student based on the outputs of Excel

Statistical Analysis
From **Table (04)** and **Figure (01)**, we observe that the number of females is higher than males**,** with females representing **62.5%** of the sample, while males account for **37.5%**.

2. Distribution of Sample Members by Age

Table (05): Distribution of Sample Members by Age

Age Group	Frequency	Percentage (%)
Under 25 years	06	15%
25 - 35 years	09	22.5%
36 - 45 years	21	52.5%
46 years and above	04	10%
Total	40	100%

Source: Prepared by the researcher based on SPSS V22 outputs.

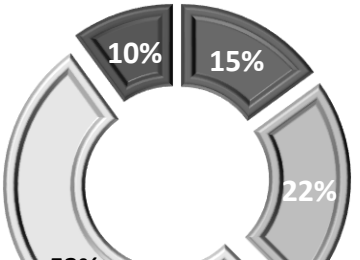

Figure (02): Distribution of sample members by age variable**Source:** Prepared by the student based on the outputs of Excel

Statistical Analysis

From **Table (05)** and **Figure (02)**, we observe that the majority of the sample falls within the 36 to 45 age group (52.5%)**,** followed by those aged 25 to 35 years (22.5%)**.** The under 25 age group accounts for 15%**,** while those 46 years and above represent the lowest percentage at 10%**.**

3. Distribution of Sample Members by Educational Level

Table (06): Distribution of Sample Members by Educational Level

Educational Level	Frequency	Percentage (%)
Secondary	02	5%
Vocational	04	10%
University	25	62.5%
Postgraduate	09	22.5%
Total	40	100%

Source: Prepared by the researcher based on Excel outputs**.**

Figure (03): Distribution of sample members according to the educational level variable

Statistical Analysis

From **Table (06)** and **Figure (03)**, it is observed that the majority of the sample members hold a university degree (62.5%)**,** followed by those with postgraduate studies (22.5%)**.** Individuals with a vocational education level make up 10%**,** while those with a secondary education level constitute the lowest percentage at 5%.

4. Distribution of Sample Members by Professional Experience

Table (07): Distribution of Sample Members by Professional Experience

Professional Experience	Frequency	Percentage (%)
Less than 5 years	02	5%
5 to 10 years	06	15%
11 to 15 years	10	25%
More than 15 years	22	55%
Total	40	100%

Source: Prepared by the researcher based on SPSS22 outputs**.**

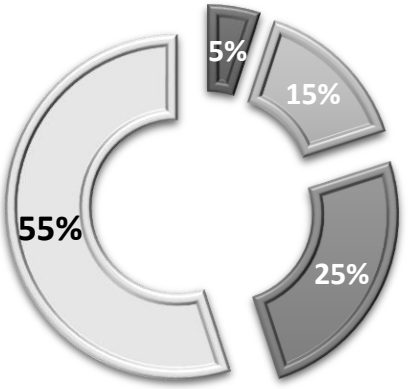

Figure (04): Distribution of Sample Members by Professional Experience Variable
Source: Prepared by the student based on the outputs of Excel Statistical Analysis

From **Table (07)** and **Figure (04)**, it is observed that the majority of the sample members have more than 15 years of professional experience (55%)**,** followed by those with 11 to 15 years of experience (25%)**.** Individuals with 5 to 10 years of experience account for 15%**,** while those with less than 5 years of experience represent the lowest percentage at 5%**.**

5. Distribution of Sample Members by Job Position

Table (08): Distribution of Sample Members by Job Position

Job Position	Frequency	Percentage (%)

Job Position	Frequency	Percentage (%)
Agency Director	01	2.5%
Deputy Director	03	7.5%
Department Head	10	25%
Employees	26	65%
Total	40	100%

Source: Prepared by the researcher based on SPSS22 outputs**.**

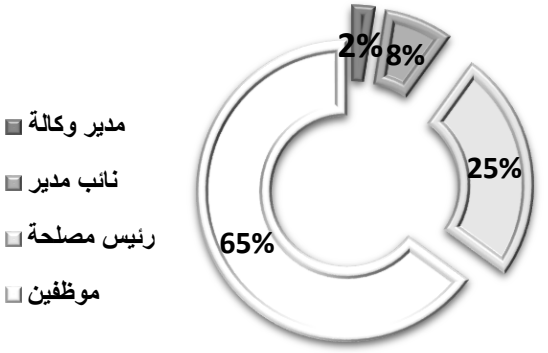

Figure (05): Distribution of Sample Members by Job Status Variable
Source: Prepared by the student based on the outputs of Excel Statistical Analysis

Statistical Analysis of Sample Trends on the Rational Use of Non-Renewable Energy Sources

1. Rational Use of Oil

Table (09): Analysis of Sample Trends on Rational Use of Oil

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Trend
Sonelgaz	71.4%	28.6%	-	-	-	4.71	0.463	Strongly

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Trend
relies on the Five-Year Work Program for oil exploitation								Agree
Sonelgaz follows APRUE agency decisions for oil exploitation	42.9%	52.4%	4.8%	-	-	4.38	0.590	Strongly Agree
Sonelgaz relies on the National Energy Control Fund for oil exploitation	57.1%	38.1%	4.8%	-	-	4.52	0.602	Strongly Agree
Overall Rational Use of Oil	-	-	-	-	-	4.54	0.598	Strongly Agree

Source: Prepared by the researcher based on SPSS22 outputs**.**

Analysis:

- The **highest-rated statement** (mean = **4.71**, SD = **0.463**) indicates that participants **strongly agree** that Sonelgaz relies on the Five-Year Work Program for oil exploitation.
- The **second-ranked statement** (mean = **4.52**, SD = **0.602**) suggests strong agreement that Sonelgaz follows National Energy Control Fund decisions for oil use.
- The **third-ranked statement** (mean = **4.38**, SD = **0.590**) indicates that participants also agree that Sonelgaz implements APRUE agency decisions for oil exploitation.
- **Conclusion:** The results confirm that all participants agree that rational oil exploitation contributes to achieving energy security at Sonelgaz in Boumerdes province**.**

Rational Utilization of Coal

Table No. (10): Analysis of Sample Members' Attitudes Towards the Rational Utilization of Coal

Rational Utilization of Coal	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Direction
Sonelgaz relies on the decisions of the Intersectoral Committee for Energy Consumption Rationalization (CIME) in its coal utilization.	9	12	-	-	-	4.43	0.507	Strongly Agree
Sonelgaz is moving towards replacing coal in electricity generation with renewable energy sources.	12	7	2	-	-	4.48	0.680	Strongly Agree
Sonelgaz uses the decisions of the APRUE agency in its coal utilization (as it does with oil).	8	12	1	-	-	4.33	0.577	Strongly Agree
Overall Rational Utilization of Coal	-	-	-	-	-	4.41	0.536	Strongly Agree

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis

From Table No. (10), which represents the analysis of sample members' attitudes towards the optimal and rational utilization of coal, we observe the following:

- **Ranked first** is statement (05)**,** with a relatively high standard deviation of 0.680 and a mean of 4.48**,** indicating that the sample members strongly agree that Sonelgaz is moving towards replacing coal in electricity generation with renewable energy sources**.**
- **In second place** are statements (04) and (06)**,** both with moderate standard deviations**:** 0.507 for statement (04) and 0.577 for statement (06)**,** and equal means of 4.33**.** This indicates that the sample members

strongly agree that Sonelgaz relies on the decisions of the Intersectoral Committee for Energy Consumption Rationalization (CIME) in its coal utilization and also strongly agree that Sonelgaz uses APRUE agency decisions in its coal utilization**.**

This suggests that all sample members agree that the optimal and rational utilization of coal contributes to achieving energy security for Sonelgaz in Boumerdes Province**.**

Rational Utilization of Natural Gas

Table No. (11): Analysis of Sample Members' Attitudes Towards the Rational Utilization of Natural Gas

Rational Utilization of Natural Gas	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Mean**	**Standard Deviation**	**Direction**
Sonelgaz works on supplying cities with natural gas instead of directing it towards energy generation.	4	9	8	-	-	3.81	0.750	Agree
Sonelgaz relies on investment in upgrading the gas-to-liquids (GTL) industry.	4	12	3	2	-	3.86	0.854	Agree
Sonelgaz proposes adopting the idea of expanding its	8	11	1	1	-	4.24	0.768	Strongly Agree

Rational Utilization of Natural Gas	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Direction
market share in natural gas exports.								
Overall Rational Utilization of Natural Gas	-	-	-	-	-	3.97	0.573	Agree

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis

From **Table No. (11)**, which presents the analysis of sample members' attitudes toward the optimal and rational utilization of coal, we observe the following:

- **Ranked first** is statement (09)**,** with a high standard deviation of 0.768 and a mean of 4.24, indicating that the sample members strongly agree that Sonelgaz proposes adopting the idea of expanding its market share in natural gas exports**.**
- **In second place** is statement (08)**,** with a very high standard deviation of 0.854 and a mean of 3.86, indicating that the sample members agree that Sonelgaz relies on investment in upgrading the gas-to-liquids (GTL) industry**.**
- **Ranked third** is statement (07)**,** with a high standard deviation of 0.750 and a mean of 3.81**,** indicating that the sample members agree that Sonelgaz works on supplying cities with natural gas instead of directing it toward energy generation**.**

This implies that all sample members agree that the optimal and rational utilization of natural gas contributes to achieving energy security for Sonelgaz in Boumerdes Province**.**

Table No. (12): Analysis of Sample Members' Attitudes Towards the Rational Utilization of Non-Renewable Energy Sources

Dimension	Mean	Standard Deviation	Direction
Rational Utilization of Oil	4.54	0.598	Strongly Agree
Rational Utilization of Coal	4.41	0.536	Strongly Agree
Rational Utilization of Natural Gas	3.97	0.573	Agree
Overall Rational Utilization of Non-Renewable Energy Sources	4.31	0.573	Strongly Agree

Source: Prepared by the researcher based on SPSS22 output.

Table No. (13): Analysis of Sample Members' Attitudes Towards the Shift to Solar Energy Consumption

Shift to Solar Energy Consumption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Direction
Sonelgaz relies on solar energy for electricity generation.	13	08	-	-	-	4.62	0.498	Strongly Agree
Sonelgaz relies on solar energy for material smelting and crop drying.	09	11	01	-	-	4.38	0.590	Strongly Agree
Sonelgaz relies on solar energy for heating and cooling.	10	11	0	-	-	4.48	0.512	Strongly Agree
Overall shift to solar energy consumption.	-	-	-	-	-	4.49	0.532	Strongly Agree

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis

From **Table No. (13)**, which presents the analysis of sample members' attitudes toward the shift to solar energy consumption, we observe the following:

- **Ranked first** is statement (01)**,** with a moderate standard deviation of 0.498 and a mean of 4.62, indicating that the sample members strongly agree that Sonelgaz relies on solar energy for electricity generation.
- **In second place** is statement (03)**,** with a moderate standard deviation of 0.512 and a mean of 4.48, indicating that the sample members strongly agree that Sonelgaz relies on solar energy for material smelting and crop drying**.**
- **Ranked third** is statement (02), with a moderate standard deviation of 0.590 and a mean of 4.38, indicating that the sample members strongly agree that Sonelgaz relies on solar energy for heating and cooling**.**

This implies that all sample members agree that shifting to solar energy consumption contributes to achieving energy security for Sonelgaz in Boumerdes Province**.**

2. Shift Towards Wind Energy Consumption

Table No. (14): Analysis of Sample Members' Attitudes Towards the Shift to Wind Energy Consumption

Shift to Wind Energy Consumption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Direction
Sonelgaz relies on wind energy for electricity generation.	03	06	11	01	-	2.48	0.814	Disagree
Sonelgaz relies on wind energy for ship propulsion instead of fossil fuel (turbines).	02	07	06	06	-	2.76	0.995	Neutral
Sonelgaz relies on wind energy for water pumping.	02	08	04	07	-	2.76	1.044	Neutral
Overall shift to wind energy consumption.	-	-	-	-	-	2.66	0.712	Neutral

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis

From **Table No. (14)**, which presents the analysis of sample members' attitudes toward the shift to wind energy consumption, we observe the following:

- **Ranked first** is statement (05)**,** with a very high standard deviation of 0.995 and a mean of 2.76, indicating that the sample members are neutral regarding Sonelgaz's reliance on wind energy for ship propulsion instead of fossil fuel (turbines)**.**
- **In second place** is statement (06)**,** with a very high standard deviation of 1.044 and a mean of 2.76, indicating that the sample members are neutral regarding Sonelgaz's reliance on wind energy for water pumping**.**

- **Ranked third** is statement (04)**,** with a very high standard deviation of 0.814 and a mean of 2.48, indicating that the sample members disagree that Sonelgaz relies on wind energy for electricity generation**.**

This implies that the overall attitude of the sample towards shifting to wind energy consumption remains neutral regarding its role in ensuring energy security for Sonelgaz in Boumerdes Province**.**

3. Shift Towards Hydropower Consumption

Table No. (15): Analysis of Sample Members' Attitudes Towards the Shift to Hydropower Consumption

Shift to Hydropower Consumption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation	Direction
Sonelgaz relies on hydropower for electricity generation (tidal energy).	12	06	02	01	-	4.38	0.865	Strongly Agree
Sonelgaz relies on hydropower for operating water wheels to grind grains.	11	08	01	01	-	4.38	0.805	Strongly Agree
Sonelgaz relies on hydropower for pumping water and driving water wheels for irrigation.	08	11	01	01	-	4.24	0.768	Strongly Agree
Overall shift to hydropower consumption.	-	-	-	-	-	4.33	0.798	Strongly Agree

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis
From **Table No. (15)**, which presents the analysis of sample members' attitudes toward the shift to hydropower consumption, we observe the following:

- **Ranked first** is statement (07), with a standard deviation of 0.865 and a mean of 4.38, indicating that the sample members strongly agree that Sonelgaz relies on hydropower for electricity generation (tidal energy)**.**
- **In second place** is statement (08)**,** with a standard deviation of 0.805 and a mean of 4.38, indicating that the sample members strongly agree that Sonelgaz relies on hydropower for operating water wheels to grind grains**.**
- **Ranked third** is statement (09)**,** with a standard deviation of 0.768 and a mean of 4.24, indicating that the sample members strongly agree that Sonelgaz relies on hydropower for pumping water and driving water wheels for irrigation**.**

This implies that the overall attitude of the sample towards shifting to hydropower consumption is strongly positive, recognizing its role in ensuring energy security for Sonelgaz in Boumerdes Province**.**

4. Shift Towards Geothermal Energy Consumption

Table No. (16): Analysis of Sample Members' Attitudes Towards the Shift to Geothermal Energy Consumption

Shift to Geothermal Energy Consumption	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Mean**	**Standard Deviation**	**Direction**
Sonelgaz relies on geothermal energy for electricity generation.	02	14	04	01	-	2.19	0.680	Disagree
Sonelgaz relies on geothermal energy as mechanical energy, such as in vehicles.	01	04	07	08	01	3.19	0.981	Neutral
Sonelgaz relies on geothermal energy as radiant energy.	0	04	08	08	01	3.29	0.845	Neutral
Overall shift to geothermal energy consumption.	-	-	-	-	-	2.89	0.756	Neutral

Source: Prepared by the researcher based on SPSS22 output.

Statistical Analysis

From **Table No. (16)**, which presents the analysis of sample members' attitudes toward the shift to geothermal energy consumption, we observe the following:

- **Ranked first** is statement (12)**,** with a standard deviation of 0.845 and a mean of 3.29, indicating that the sample members are neutral regarding Sonelgaz's use of geothermal energy as radiant energy.
- **In second place** is statement (11)**,** with a standard deviation of 0.981 and a mean of 3.19, indicating that the sample members are neutral regarding Sonelgaz's use of geothermal energy as mechanical energy, such as in vehicles**.**
- **Ranked third** is statement (10)**,** with a standard deviation of 0.680 and a mean of 2.19, indicating that the sample members disagree that Sonelgaz relies on geothermal energy for electricity generation**.**

This implies that the overall attitude of the sample towards shifting to geothermal energy consumption is neutral, with some disagreement regarding its role in electricity generation**.**

Table No. (17): Analysis of Sample Members' Attitudes Towards the Shift to Renewable Energy Consumption

Dimension Trends	**Arithmetic Mean**	**Standard Deviation**	**Trend**
Trend towards solar energy consumption	4.49	0.532	Strongly Agree
Trend towards wind energy consumption	2.66	0.712	Neutral
Trend towards hydropower consumption	4.33	0.798	Strongly Agree
Trend towards geothermal energy consumption	2.89	0.756	Neutral
Trend towards renewable energy consumption	3.59	0.558	Agree

Source: Prepared by the student based on SPSS22 program outputs.

Conclusion

Achieving energy security is an economic necessity that every country must prioritize. Indicators suggest that Algeria's energy security may be affected in the future due to increasing energy consumption levels. Therefore, it is essential to work on reducing the consumption of non-renewable energy sources, as they will eventually be depleted. Instead, a shift towards renewable energy consumption is necessary, as these sources are sustainable and have minimal costs compared to non-renewable energy sources.

Key Findings:

Rational utilization of non-renewable energy sources contributes to achieving energy security at Sonelgaz (Boumerdes branch) through:

- Rational use of oil
- Rational use of coal
- Rational use of natural gas

Shifting towards renewable energy consumption contributes to achieving energy security at Sonelgaz (Boumerdes branch) through:

- Adoption of solar energy
- Adoption of wind energy
- Adoption of hydropower
- Adoption of geothermal energy

Recommendations and Suggestions:

- The need to control factors contributing to increased energy consumption in Algeria.
- Replacing energy consumption reduction policies with alternative policies and strategies, such as utilizing renewable energy sources to enhance energy production.

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