Affordable and Clean Energy

**Course Title: Affordable and Clean Energy (SDG 7) with Earth Observations**

**Unit 1: Introduction to SDG 7 and Global Energy Challenges**

**Key Topics:**

* Lesson1: Overview of SDG 7: The importance of access to affordable, reliable, sustainable, and modern energy.
  + <https://youtu.be/mmSbX1Rg2L0?si=qL_NGXhQk4aSE167>
* Lesson2: Global energy challenges: Fossil fuel dependency, energy poverty, and the need for renewable energy.
  + <https://youtu.be/-RSrviqvAmY?si=z19GOxZVFYL4Pwco>
* Lesson3: Introduction to Earth observation and satellite data in monitoring energy use and environmental impacts.
  + <https://youtu.be/Wmagqj7_c8w?si=McgQXh2ZORtJLFWN>

**Activity:**

* **Interactive Data Visualization**: Using **NASA Earthdata Worldview**, students explore satellite imagery of energy plants (solar, wind, fossil fuel) in Egypt and other countries. They compare the environmental impact of different types of energy production.
  + <https://worldview.earthdata.nasa.gov/?v=-179.435458264434,-62.40013458682887,149.13526176479124,81.68029096039362&l=Reference_Labels_15m(hidden),Reference_Features_15m(hidden),Coastlines_15m,VIIRS_SNPP_DayNightBand_At_Sensor_Radiance,VIIRS_SNPP_DayNightBand_AtSensor_M15(hidden),VIIRS_SNPP_CorrectedReflectance_TrueColor(hidden)&lg=true&tr=black_marble_night_lights&t=2022-02-06-T00%3A00%3A00Z>

**Assessment:**

* **Quiz**: Test students on the significance of energy for sustainable development and basic satellite data concepts.

**1.** What is the primary goal of SDG 7?

* A) Ensure access to affordable, reliable, sustainable, and modern energy for all.
* B) Reduce fossil fuel dependency.
* C) Improve educational systems worldwide.
* D) Promote the use of nuclear energy globally.

**Answer**: A) Ensure access to affordable, reliable, sustainable, and modern energy for all.

**2.** Which of the following is a major global energy challenge?

* A) Overuse of renewable energy
* B) Lack of fossil fuels
* C) Energy poverty in developing countries
* D) Excessive use of wind energy in rural areas

**Answer**: C) Energy poverty in developing countries

**3.** How does NASA Earth observation data contribute to SDG 7?

* A) It provides real-time satellite data to track energy usage and environmental conditions.
* B) It replaces the need for local energy monitoring systems.
* C) It produces fossil fuel data for commercial purposes.
* D) It eliminates the need for renewable energy.

**Answer**: A) It provides real-time satellite data to track energy usage and environmental conditions.

**4.** Which of the following energy sources is NOT renewable?

* A) Solar energy
* B) Wind energy
* C) Coal energy
* D) Hydroelectric energy

**Answer**: C) Coal energy

**5.** What platform can be used to visualize global energy data using satellite imagery?

* A) NASA Earthdata Worldview
* B) Google Maps
* C) Microsoft Excel
* D) YouTube

**Answer**: A) NASA Earthdata Worldview

**Unit 2: Egypt’s Energy Landscape and the Role of Renewable Energy**

**Key Topics:**

* Lesson1: Overview of Egypt’s energy production: Fossil fuels, hydroelectric, solar, and wind power.
  + Read:

Egypt's energy production is primarily based on fossil fuels, but it also has significant renewable energy resources. Here are some details about Egypt's energy production:

* Fossil fuels

Egypt is a major producer of hydrocarbons and is Africa's largest producer of fossil gas. In 2022, Egypt was the second-largest natural gas producer in Africa, and in 2023 it was the second-largest non-OPEC producer of liquid fuels. In 2022, Egypt produced nearly 62% of its energy from natural gas and 36.33% from petroleum and other liquids.

* Renewable energy

Egypt's renewable energy sources include hydro, wind, and solar. In 2023, hydro accounted for 7% of Egypt's electricity, while wind and solar accounted for 5%.

* Electricity generation

Egypt's electricity is generated in two ways: thermal power, which uses heat from burning fuels or nuclear reactions, and capturing energy from natural forces like the sun, wind, or moving water.

* Energy consumption

Egypt's energy consumption has been increasing, peaking in 2021 and 2022. In 2022, Egypt consumed 4.05 quadrillion British thermal units (Btu) of primary energy, which was higher than the 3.89 quadrillion Btu it produced.

* Emissions

Egypt's per capita emissions are lower than the global average. In 2023, Egypt increased its target to reduce greenhouse gas emissions by 37% by 2030

* Lesson2: The role of renewable energy in achieving Egypt’s Vision 2030.
* Read

**The Role of Renewable Energy in Achieving Egypt's Vision 2030**

Egypt’s Vision 2030 is a comprehensive roadmap aimed at promoting sustainable development across economic, social, and environmental dimensions. A key pillar of this vision is the transition to renewable energy, which plays a critical role in Egypt’s strategy to achieve sustainable growth, reduce carbon emissions, and secure energy independence. Renewable energy is not only essential for meeting Egypt’s growing energy demands but also aligns with global efforts, including the United Nations Sustainable Development Goals (SDGs), particularly SDG 7, which aims to ensure access to affordable, reliable, and sustainable energy for all.

**Egypt's Commitment to Renewable Energy in Vision 2030**

The Vision 2030 framework emphasizes a shift from reliance on fossil fuels toward a diversified energy mix, with a significant share coming from renewable sources like solar, wind, and hydropower. This transition is seen as critical for achieving both economic competitiveness and environmental sustainability.

**Key Objectives for Renewable Energy in Vision 2030:**

1. **Diversification of Energy Sources**: Egypt aims to diversify its energy portfolio by increasing the share of renewable energy in its overall energy mix. The goal is for renewable energy to contribute around 42% of Egypt’s total electricity generation by 2035, as outlined in the Integrated Sustainable Energy Strategy (ISES). Vision 2030 reinforces this goal by encouraging investment and innovation in renewable energy technologies.
2. **Energy Security and Independence**: A core element of Vision 2030 is achieving energy security through sustainable and independent energy sources. By harnessing its abundant solar and wind resources, Egypt seeks to reduce its reliance on imported fossil fuels, thus enhancing its energy independence and securing stable energy supply for future generations.
3. **Economic Growth and Job Creation**: The renewable energy sector is expected to drive significant economic growth by creating jobs, attracting foreign investment, and supporting the development of green industries. Solar and wind farms, for instance, are generating employment opportunities in construction, maintenance, and technological innovation, contributing to Egypt's broader economic goals.
4. **Environmental Sustainability**: Reducing greenhouse gas emissions and minimizing the environmental impact of energy production is another vital goal of Vision 2030. Transitioning to renewable energy helps Egypt meet its climate targets, reduces air pollution, and mitigates the impacts of climate change, particularly in relation to water resources, agriculture, and public health​(egypt2030).

**Major Renewable Energy Projects in Egypt**

Several large-scale renewable energy projects are pivotal to Egypt’s Vision 2030:

* **Benban Solar Park**: One of the largest solar parks in the world, located in Aswan, is a cornerstone of Egypt’s renewable energy strategy. The park has a capacity of 1.8 GW and serves as a model for future solar energy projects across the region.
* **Gulf of Suez Wind Farm**: Egypt’s wind energy capacity is also growing, with the Gulf of Suez Wind Farm being one of the largest wind power projects in the country, contributing to the diversification of renewable energy sources.
* **Hydropower**: The Aswan High Dam and other hydropower stations continue to play an important role in Egypt’s energy mix, providing clean energy while supporting water management and agricultural needs​(egypt2030).

**Challenges and Solutions**

Despite significant progress, there are challenges in scaling up renewable energy in Egypt, including:

* **Financing and Investment**: Expanding renewable energy infrastructure requires substantial financial investment. Egypt is addressing this by creating favorable policies to attract foreign and domestic investors and working with international organizations to secure funding for renewable energy projects.
* **Grid Infrastructure**: Integrating large amounts of renewable energy into the national grid poses technical challenges. Egypt’s Vision 2030 includes plans to modernize its energy infrastructure to improve grid stability and facilitate the integration of renewable energy.

**Conclusion**

Renewable energy is central to Egypt’s Vision 2030, aligning with the country’s goals of achieving economic sustainability, environmental stewardship, and energy security. By expanding its renewable energy portfolio, Egypt not only supports its own development but also contributes to global efforts to combat climate change and promote sustainable growth. The success of renewable energy projects like the Benban Solar Park is a testament to Egypt’s commitment to a greener future.

**Activity:**

* **Case Study**: Using satellite images from **NASA Earth Observatory**, students study the **Benban Solar Park** and other renewable energy projects in Egypt. They analyze the impact of these projects on reducing emissions and providing energy to rural areas.
  + <https://sedac.ciesin.columbia.edu/mapping/viewer/>

**Assessment:**

* **Quiz**: Test students’ knowledge of Egypt’s energy landscape and renewable energy’s role in Vision 2030.

**1.** What is one of Egypt’s primary renewable energy sources?

* A) Coal
* B) Solar energy
* C) Oil
* D) Nuclear power

**Answer**: B) Solar energy

**2.** What is Egypt’s Vision 2030 in relation to energy?

* A) A plan to transition Egypt’s energy landscape to cleaner, renewable energy sources.
* B) A policy to increase fossil fuel production.
* C) A strategy to reduce the cost of energy by using coal.
* D) A goal to completely remove energy subsidies.

**Answer**: A) A plan to transition Egypt’s energy landscape to cleaner, renewable energy sources.

**3.** How does the **Benban Solar Park** contribute to SDG 7 in Egypt?

* A) By providing free electricity to urban areas.
* B) By being one of the largest solar energy parks, reducing dependence on fossil fuels.
* C) By reducing the need for renewable energy.
* D) By replacing wind energy entirely.

**Answer**: B) By being one of the largest solar energy parks, reducing dependence on fossil fuels.

**4.** Which NASA resource can students use to explore Egypt's energy projects like the Benban Solar Park?

* A) NASA Earth Observatory
* B) NASA’s Apollo Program
* C) NASA’s SpaceX Collaboration
* D) NASA’s Mars Rover

**Answer**: A) NASA Earth Observatory

**5.** What is one challenge Egypt faces in expanding renewable energy access to rural areas?

* A) Lack of sufficient sunlight
* B) High costs and infrastructure limitations
* C) Overproduction of solar energy
* D) Inadequate fossil fuel reserves

**Answer**: B) High costs and infrastructure limitations

**Unit 3: Innovations in Clean Energy and Satellite Monitoring**

**Key Topics:**

* Lesson1: Innovations in renewable energy: Solar, wind, hydropower, and energy storage.
  + <https://youtu.be/DZm9OFyGlBY?si=sJra68LfsHJhYKfw>
* Lesson2: Satellite monitoring of energy infrastructure and environmental impact using Earth observation data.
  + Read: <https://www.dnv.com/services/satellite-based-remote-sensing-for-energy-infrastructure-141223/#:~:text=Remote%20sensing%20by%20means%20of,decision%20support%20and%20risk%20management>.
* Lesson3: The role of digital technologies (AI, IoT) in managing clean energy systems.
  + <https://youtu.be/X2eYdAR0ka4?si=p8WQtjrx9V5PVbXP>

**Activity:**

* **Hands-On Workshop**: Students use data from **NASA ARSET** and **EODMS** to track energy infrastructure in Egypt and propose solutions to increase energy efficiency. They can simulate the expansion of solar and wind farms using data on land use and sunlight availability.
  + <https://www.eodms-sgdot.nrcan-rncan.gc.ca/index-en.html>

**Assessment:**

* **Quiz**: Focus on key clean energy technologies and how satellite data can help monitor energy efficiency.

**1.** Which of the following is a major innovation in renewable energy technology?

* A) Fossil fuel extraction
* B) Energy storage technologies like batteries and hydrogen fuel cells
* C) Building more coal plants
* D) Storing energy in wooden barrels

**Answer**: B) Energy storage technologies like batteries and hydrogen fuel cells

**2.** What is the role of satellite monitoring in renewable energy?

* A) Satellites monitor fossil fuel extraction for commercial purposes.
* B) Satellites track energy production and environmental impacts of energy infrastructure.
* C) Satellites are used to store solar energy.
* D) Satellites replace local energy plants.

**Answer**: B) Satellites track energy production and environmental impacts of energy infrastructure.

**3.** Which NASA resource provides training on using satellite data to support SDG 7?

* A) NASA ARSET
* B) NASA Apollo Mission
* C) NASA SpaceX Initiative
* D) NASA Mars Rover

**Answer**: A) NASA ARSET

**4.** What clean energy technology uses the power of moving water to generate electricity?

* A) Solar panels
* B) Wind turbines
* C) Hydropower
* D) Fossil fuels

**Answer**: C) Hydropower

**5.** What type of energy is derived from the heat beneath the Earth’s surface?

* A) Geothermal energy
* B) Solar energy
* C) Wind energy
* D) Nuclear energy

**Answer**: A) Geothermal energy

**Unit 4: Overcoming Barriers to Universal Energy Access in Egypt**

**Key Topics:**

* Lesson1: Barriers to clean energy access in Egypt: Geographic disparities, cost, infrastructure, and fossil fuel dependency.
  + <https://youtu.be/jiPAaUQ9MAs?si=f9QJinPQohJ4AMgc>
* Policies and partnerships for expanding energy access in rural and underserved areas.
  + <https://youtu.be/77iIBEA54F8?si=kco8PMTzzRtLz_1W>
* Using satellite data and Earth observations to monitor energy projects and assess their impact on communities.
  + Read:

By utilizing satellite data and Earth observations, energy projects can be effectively monitored to assess their impact on surrounding communities, providing insights into land use changes, environmental effects like air quality and vegetation health, and potential social impacts through analysis of population density and infrastructure alterations, all with a wide-scale and objective perspective that complements traditional ground-based monitoring methods.

Key aspects of using satellite data for energy project monitoring:

* Land Use Changes:
  + Before and after analysis: Compare satellite imagery taken before a project begins construction with images during and after development to identify changes in land cover, like deforestation or altered land use patterns due to project infrastructure.
  + Vegetation monitoring: Assess changes in vegetation health using Normalized Difference Vegetation Index (NDVI) to identify areas impacted by construction or altered water availability.
* Environmental Impacts:
  + Air quality monitoring: Analyze satellite data to monitor air pollution levels, particularly in areas surrounding power plants, by detecting particulate matter concentrations.
  + Water quality assessment: Monitor changes in water bodies, including potential impacts on water quality and turbidity, near hydroelectric dams or water storage facilities.
  + Land surface temperature analysis: Detect changes in ground temperature patterns, which can indicate heat islands around urban areas with high energy consumption.
* Community Impact Assessment:
  + Population density analysis: Utilize high-resolution satellite imagery to assess population density around project sites to understand potential social impacts on communities.
  + Infrastructure changes: Monitor changes in infrastructure development, like new roads or buildings, related to an energy project.

Relevant Satellite Data Sources:

* Landsat:

Provides high-resolution imagery for land cover analysis and change detection.

* Sentinel Satellites (Copernicus Program):

Offers frequent revisit times and diverse data types for monitoring various environmental parameters.

* MODIS (Moderate Resolution Imaging Spectroradiometer):

Useful for large-scale monitoring of vegetation health and environmental changes.

* VIIRS (Visible Infrared Imaging Radiometer Suite):

Can be used for nighttime light analysis to assess energy consumption patterns.

Benefits of using satellite data:

* Wide Coverage:

Satellites provide broad spatial coverage, allowing for comprehensive monitoring across large project areas.

* Regular Updates:

Frequent data acquisition enables tracking changes over time and identifying potential issues early.

* Objectivity:

Satellite data can offer a more objective perspective compared to ground-based observations, reducing potential biases.

Challenges to consider:

* Data Interpretation: Requires expertise to accurately interpret satellite imagery and translate data into meaningful insights.
* Weather Conditions: Cloud cover can limit data availability in certain regions.
* Resolution limitations: Depending on the satellite sensor, resolution may not be sufficient for detailed analysis in certain areas.

**Activity:**

* **Role-Playing Exercise**: Students take on roles as government officials, energy company leaders, and community activists to develop a policy for expanding clean energy access in underserved areas of Egypt. They use satellite data from **NASA Earthdata** and **Canadian Space Agency resources** to guide their policy decisions.

<https://www.geoportal.org/>

**Assessment:**

**1.** What is one major barrier to clean energy access in Egypt’s rural areas?

* A) Too much sunlight
* B) Lack of infrastructure and funding
* C) Overabundance of wind farms
* D) High production of fossil fuels

**Answer**: B) Lack of infrastructure and funding

**2.** How can satellite data help policymakers in expanding energy access?

* A) By showing where new energy projects are needed
* B) By replacing the need for new infrastructure
* C) By producing energy directly
* D) By monitoring social media for energy trends

**Answer**: A) By showing where new energy projects are needed

**3.** Which organization provides satellite data on renewable energy access globally, including in Egypt?

* A) NASA
* B) Google
* C) Facebook
* D) The International Olympic Committee

**Answer**: A) NASA

**4.** Which Canadian Space Agency resource provides open data on climate action and energy infrastructure?

* A) Earth Observation Data Management System (EODMS)
* B) Canada’s Mars Exploration Program
* C) Canada’s SpaceX Initiative
* D) Canadian Water and Agriculture Program

**Answer**: A) Earth Observation Data Management System (EODMS)

**5.** What is the primary benefit of renewable energy in achieving SDG 7?

* A) Reducing greenhouse gas emissions while providing sustainable energy access
* B) Increasing the use of fossil fuels
* C) Replacing the need for innovation
* D) Limiting energy use to urban areas only

**Answer**: A) Reducing greenhouse gas emissions while providing sustainable energy access