Growing Satellite Data Applications for the Energy Sector

Daniel Friedland & Tracey Holloway, Ph.D. | The Nelson Institute Center for Sustainability and the Global Environment (SAGE) | The University of Wisconsin-Madison

Introduction

Satellite-based Earth observations typically offer spatially contiguous global or regional coverage, filling gaps in ground, aircraft, and drone monitors, and supplementing evidence from surveys and inventories (Eckman & Stackhouse, 2012). These data offer the potential to monitor energy sources, distribution, consumption, impacts, and risks (Edwards et al., 2022). As shown in **Figure 1**, the U.S. energy system includes a wide range of fuel and technology sources (left column), consumption sectors (right column), and distribution formats, including electricity generation (Lawrence Livermore National Laboratory, 2024).

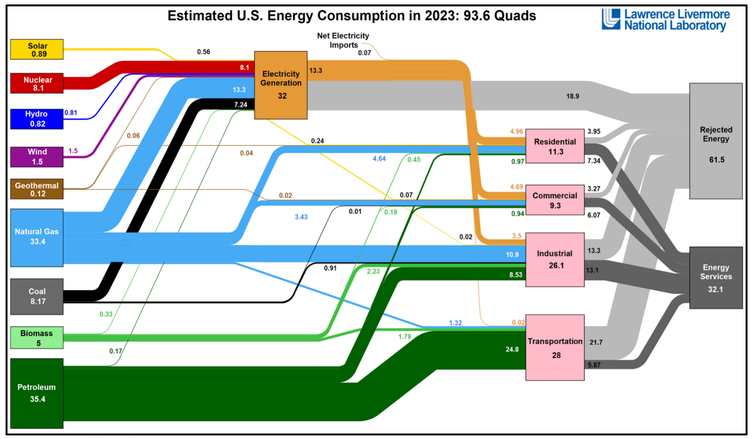

Figure 1: 2023 U.S. energy consumption, estimated by the Lawrence Livermore National Laboratory, based on data gathered by the Department of Energy (2024).

Building on the decade-long success of NASA HAQAST in connecting NASA Earth Observations with user needs, in 2025, the University of Wisconsin-Madison launched the NASA Commercial Impact Hub (CIH). The project broadens the use of NASA data in the private energy sector by documenting successes, identifying opportunities, and building partnerships for future data applications.

Acknowledgements

This work is funded by the NASA Energy Resources Program.

Interested/active in satellite data applications for energy? Let's talk!

dfriedland2@wisc.edu

References

Earth Observation Group, Payne Institute for Public Policy. (2025). *VIIRS Nightfire (VNF) Version 4.0* [Data set]. https://eogdata.mines.edu/products/vnf/vnf_v40.html

Eckman, R. S., & Stackhouse, P. W. (2012). CEOS contributions to informing energy management and policy decision making using space-based Earth observations. Applied Energy, 90(1), 206–210. https://doi.org/10.1016/j.apenergy.2011.03.001

Edwards, M. R. et al. (2022). Satellite data applications for sustainable energy transitions. Frontiers in Sustainability, 3, 910924. https://doi.org/10.3389/frsus.2022.910924

Hansen, K. (2021, February 16). *Extreme winter weather causes U.S. Blackouts*. NASA Earth Observatory. https://earthobservatory.nasa.gov/images/147941/extreme-winter-weather-causes-us-blackouts

Landsat 8 | U. S. Geological Survey. (2018, February 1). https://www.usgs.gov/landsat-missions/landsat-8

Lawrence Livermore National Laboratory. (2024). *Estimated U.S. energy consumption in 2023* [Flowchart]. U.S. Department of Energy. https://flowcharts.llnl.gov.

NASA VIIRS Land Science Investigator-Led Processing System. (2024). *VIIRS/NPP daily gridded day night band 500 m linear lat lon grid night* [Dataset].. https://doi.org/10.5067/VIIRS/VNP46A1.002

USGS Landsat 8 level 2, collection 2, tier 1. (n.d.). [Dataset]. Earth Engine Data Catalog. https://developers.google.com/earth-engine/datasets/catalog/LANDSAT_LC08_C02_T1_L2

Energy resilience

- **Satellite Data**: NASA's Black Marble data product suite, which accesses VIIRS nighttime light data and removes nuisances such as cloud cover and atmospheric, lunar, terrain, and other interferences (Román et al, 2018).
- Aboard the Suomi NPP, NOAA-20, and NOAA-21 satellites, the Visible and Infrared Imaging Suite (VIIRS) is equipped with a day-night band (DNB) that provides ultrasensitive visible and near-infrared imagery, allowing for images to be taken at night (NASA, 2024). Imagery from the VIIRS DNB is often used to examine nighttime lights (NTL) from cities, providing insights into energy demand, access, distribution, and more.
- The Black Marble team used NTL data to visualize the extent of the power outages caused by extreme weather in Texas, as seen in Figure 2 (Hansen, 2021). This is an important application, as it shows the weak points in a city's grid, and therefore what communities might be more at risk of power outages in the future. It also allows for more educated city planning to improve resilience.

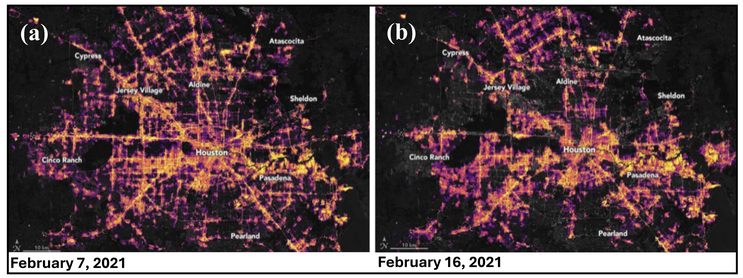

Figure 2: Black Marble NTL imagery showing the extent of the power outage in Houston, TX, following an extreme weather event. (a) Before and (b) after images are shown above. Images from NASA Earth Observatory.

Industrial emissions

- **Satellite Data:** VIIRS Nightfire (VNF) data product, courtesy of the Earth Observation Group at the Colorado School of Mines.
- By looking at infrared imagery at night, radiant emissions can be detected. From these emissions, key data can be derived, including the temperature, radiance, radiant heat, and area of the source. VIIRS Nightfire is a data access viewer that performs these calculations, allowing users to access information regarding a given emission source (EOG, 2025). VNF categorizes the different emitters, with two different catalogs: IR emitters and gas flares. Over 20,000 sites are being monitored nightly by EOG.
- For a given emitter, a temporal profile can be generated, visualizing site-specific parameters, such as radiance, temperature, and flared gas flow rate, from 2012 to 2021. An example profile is shown in **Figure 3b** from a liquified natural gas (LNG) refinery in Freeport, TX.

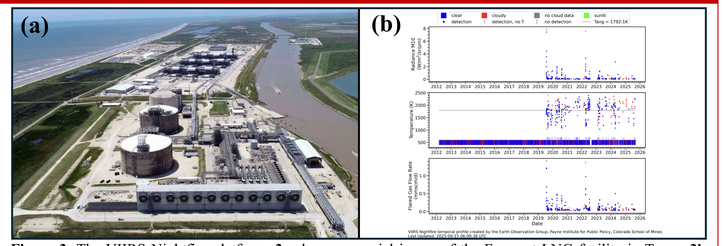

Figure 3: The VIIRS Nightfire platform. **3a** shows an aerial image of the Freeport LNG facility in Texas. **3b** shows the temporal profile of Freeport LNG. Radiance ($W/m^2/sr/\mu m$), temperature (K), and flared gas flow rate (mmscm/d) are plotted from 2012-2021.

Data center heat load

- **Satellite Data:** Landsat 8 thermal infrared sensor (TIRS), courtesy of USGS, and accessed via Google Earth Engine.
- The heat load of a data center is a major concern, as the servers within emit a lot of heat due to their high processing demands. Since there are satellites equipped with similar sensors to the in situ and handheld thermal sensors typically used, we are exploring thermal IR data from Landsat 8's TIRS instrument to assess the temperature of data centers.
- An example site, the QTS Atlanta 1 data center, was examined via Google Earth Engine using thermal imagery from Landsat 8 TIRS. The site can be seen in **Figure 4a**.
- The thermal imagery is shown in **Figure 4b**, with the data center outlined in red. The surrounding infrastructure is visibly cooler than the data center, aiding in understanding the excess heat being emitted from the facility. Future work will assess how the heat signatures of several data centers have changed over time.

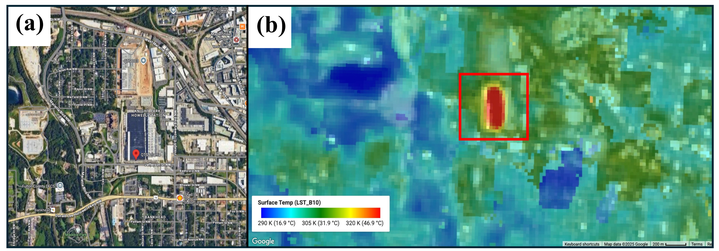

Figure 4: Imagery showing **(a)** the QTS Atlanta 1 data center using Google Maps visible satellite imagery and **(b)** the QTS Atlanta 1 data center and surrounding region using Landsat 8 Thermal Infrared Sensor (TIRS) imagery from 01-01-2022 to 06-01-2022, courtesy of USGS. The data center is outlined in red in **4b**.

Solar PV siting with NASA POWER

- **Satellite Data**: NASA POWER's all-sky surface shortwave downward irradiance
- NASA POWER is a data product suite that offers a variety of radiative and meteorological data, as measured by satellite instruments, coupled with models. Of these data, surface shortwave downward irradiance can offer insight into the amount of electricity a solar PV panel could theoretically produce by measuring the total radiant power per unit area (W/m^2) it receives.
- This data can be downloaded down to daily intervals at a 1º x 1º grid resolution, allowing for those siting solar PV farms to identify locations that will produce the most electricity.
- This irradiance is visualized in **Figure 5** at the national scale for 2024, showing variations in incident radiation on the surface throughout the year.

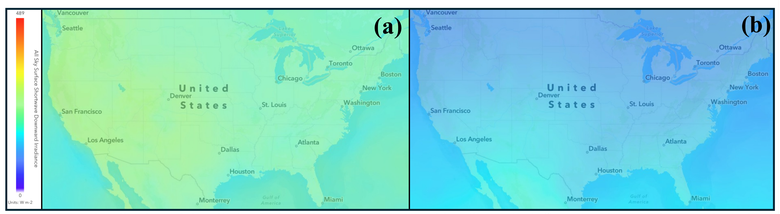

Figure 5: A visualization of the all-sky surface shortwave downward irradiance (W/m^2) across the U.S. in **(a)** July and **(b)** December of 2024, courtesy of NASA POWER.