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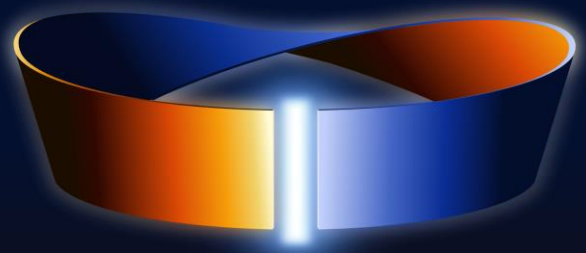


# WARP to Resilience

*Weather-Adapted Resource Planning*

# Development of future weather variants for demand forecast

Presented by ONUR AYDIN

**IEPR Commissioner Workshop on Load Modifier Scenario Development**

**August 18, 2023**

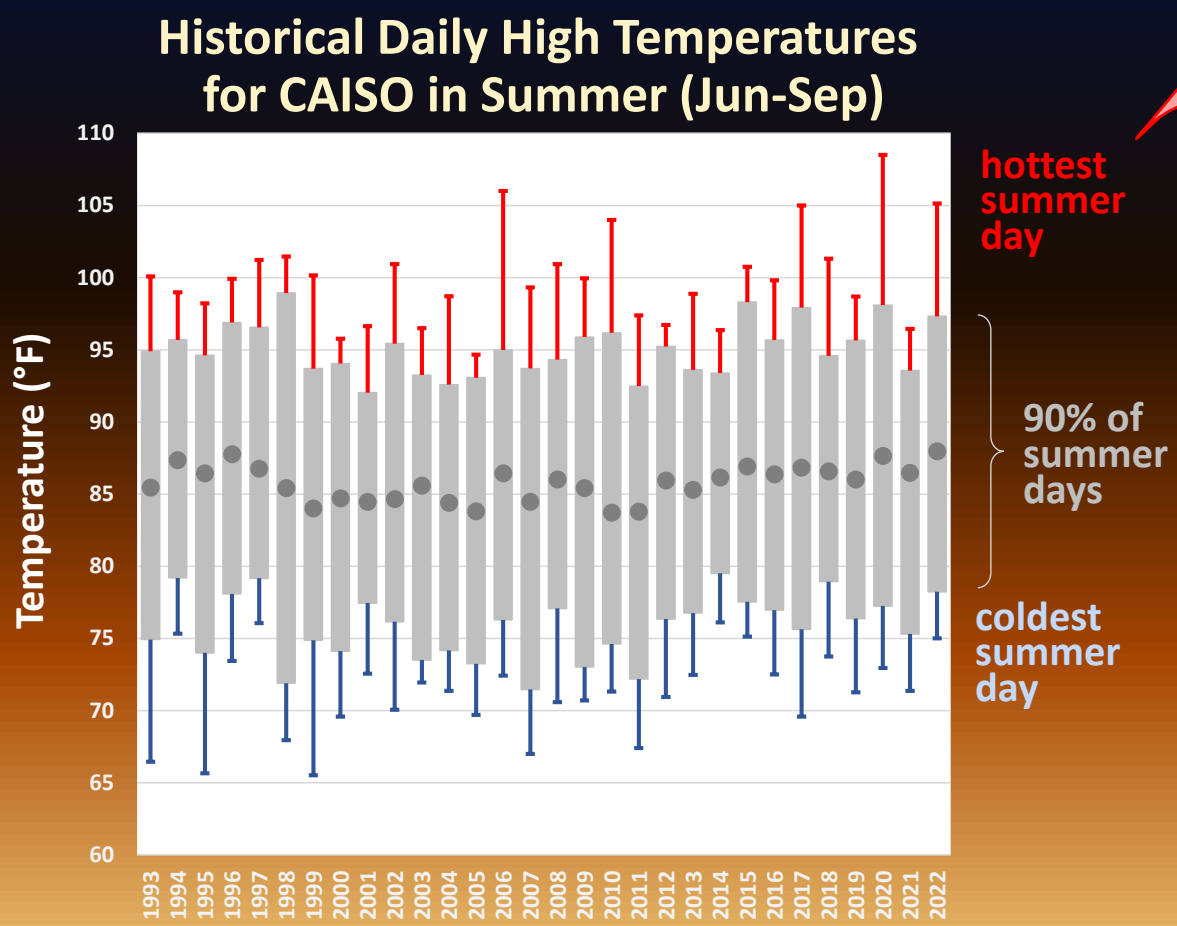
Lumen ENERGY STRATEGY

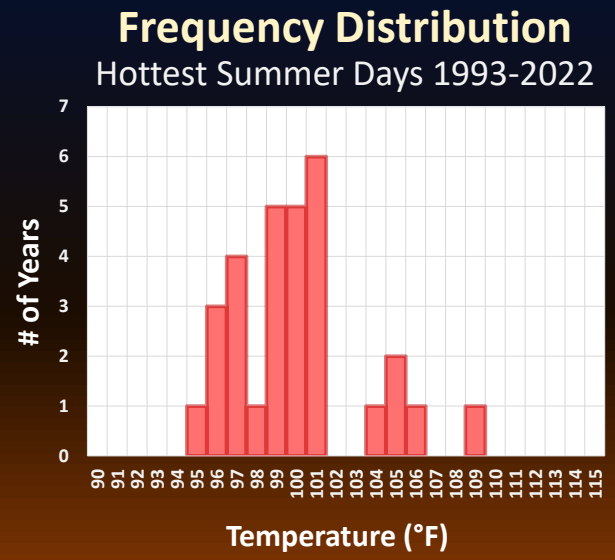
# Need for future weather variants

*Goal: Develop a set of hourly weather variants reflecting the range of potential weather outcomes in a given future year, which is essential for characterizing electricity demand forecast under normal and extreme conditions.*

- Strong relationship between temperatures and demand levels, driven by cooling-related use in summer and heating-related use in winter
- August 2020 and September 2022 heat waves underscored the importance of capturing the effects of changes in magnitude, duration, and timing of unprecedented extreme heat events
- Using a long historical record over multiple decades can expand the range of weather conditions, but data from decades ago are less representative of today and future climate conditions
- This challenge previously recognized by the CEC staff and stakeholders; Interim solutions considered shortening the historical window or applying heavier weights to more recent years, but there are inherent limitations

# Need for richer spectrum of weather events



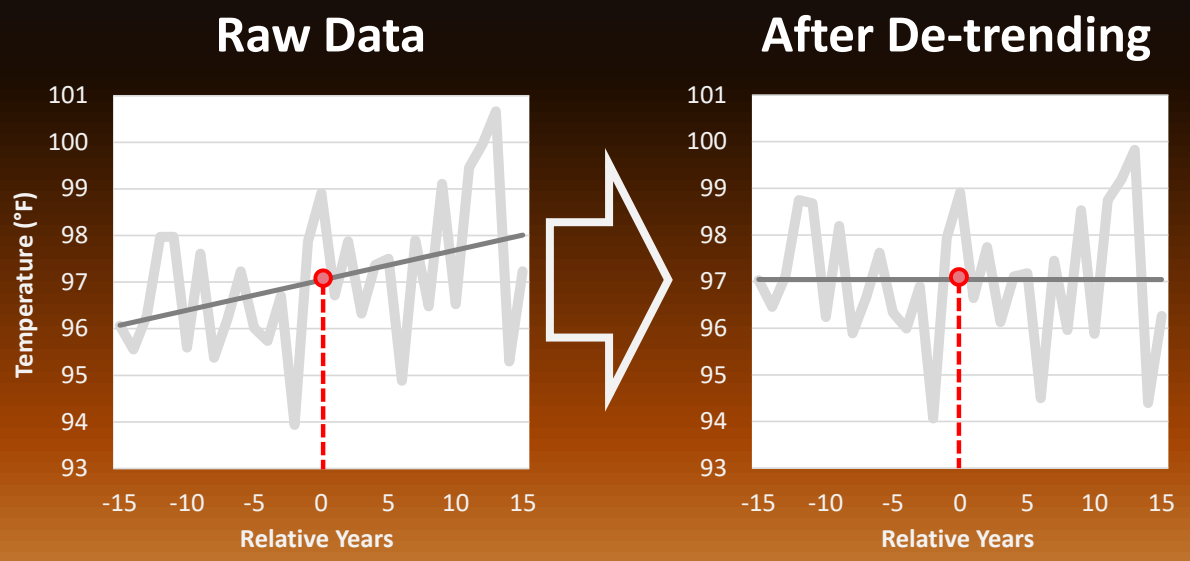




- Historical record is powerful and mostly indisputable (excluding measurement errors); but it represents just one realization of potential outcomes
- Statistical techniques can “fit” a distribution, but won’t capture emerging, novel weather patterns related to climate change

# Motivation for de-trended dataset

*Developing a de-trended hourly weather and climate data library based on latest climate projections can improve demand normalization process and can be readily integrated with the existing framework .*

*Example for Illustration*



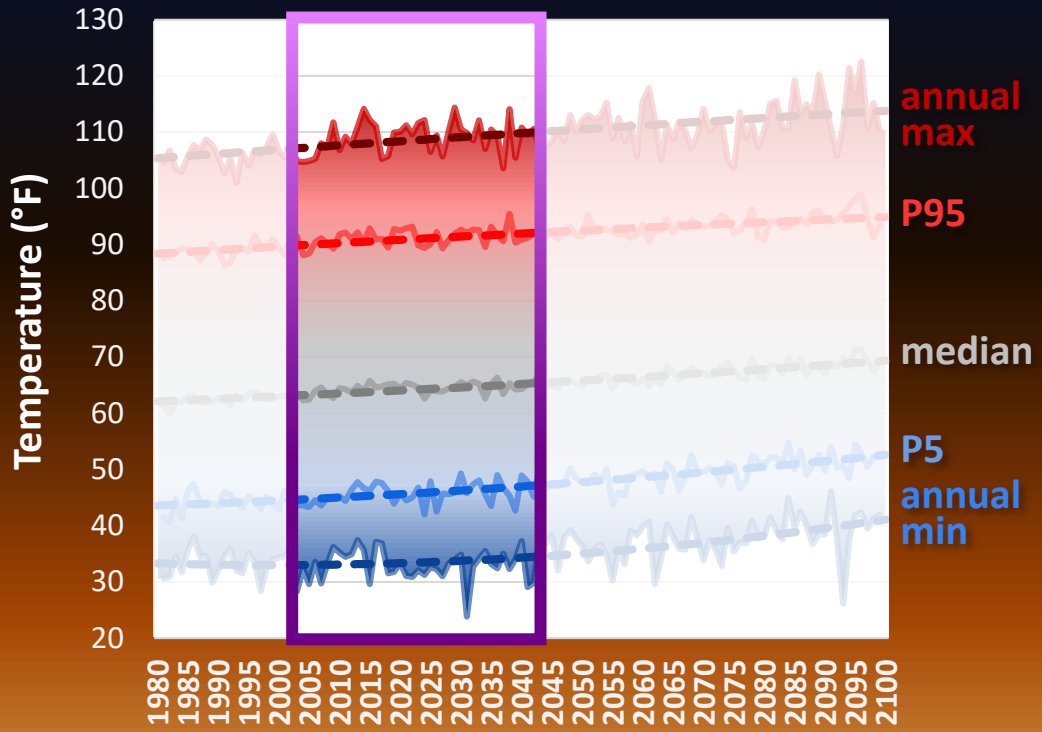

Trendline shows temperatures increase by 2°F on average from 96°F to 98°F over 30-years

De-trending centers temperatures at 97°F as the level expected for forecast year

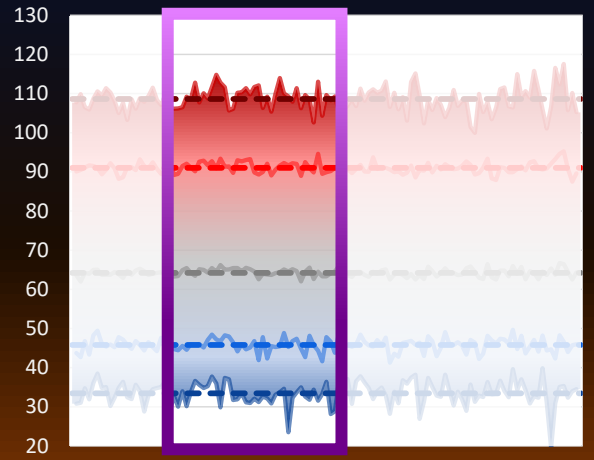
- Integrating the latest high-resolution climate projections is needed to plan for emerging, novel weather patterns
- With only a limited subset of climate simulations downscaled and localized at the hourly granularity, drawing from a rolling window of 30+ years centered around forecast year increases the size of the ensemble of weather variants needed for demand forecasting
- De-trending the projections within each window ensures that the dataset reflects the expectations of the forecast year

# De-trending by temperature levels

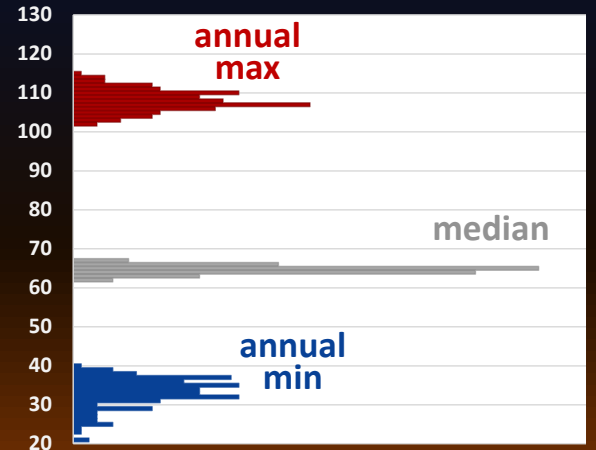
**Historical & Projected Temperatures**
Example: Riverside Station




**De-trended Temperatures**
Base Year 2023

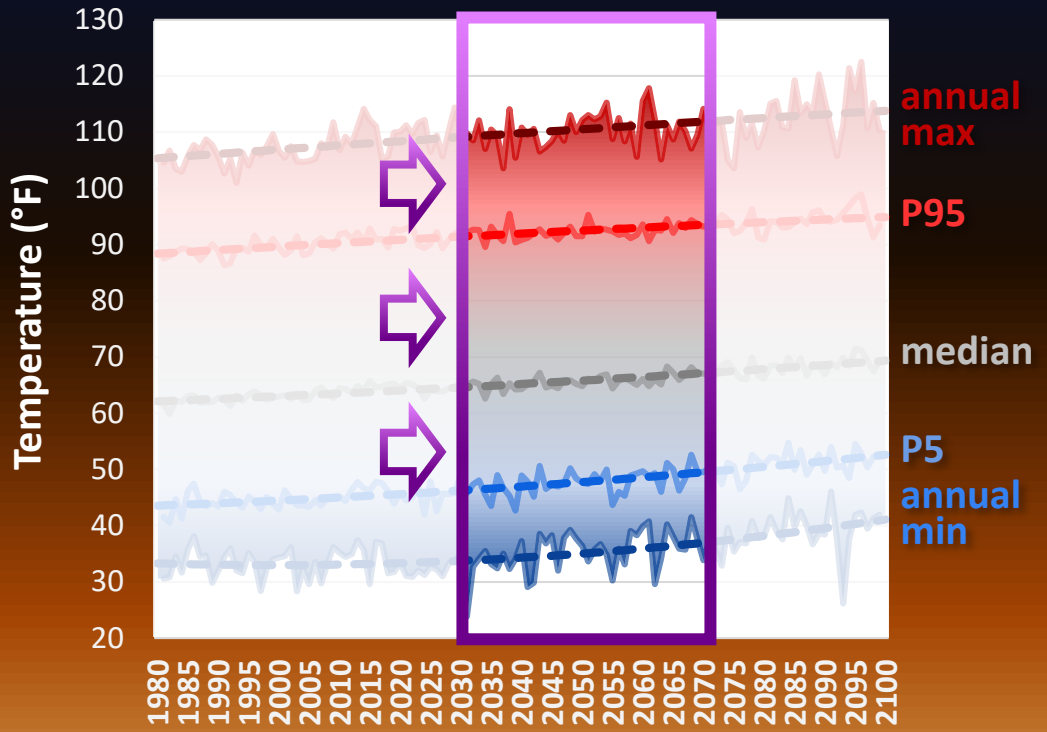


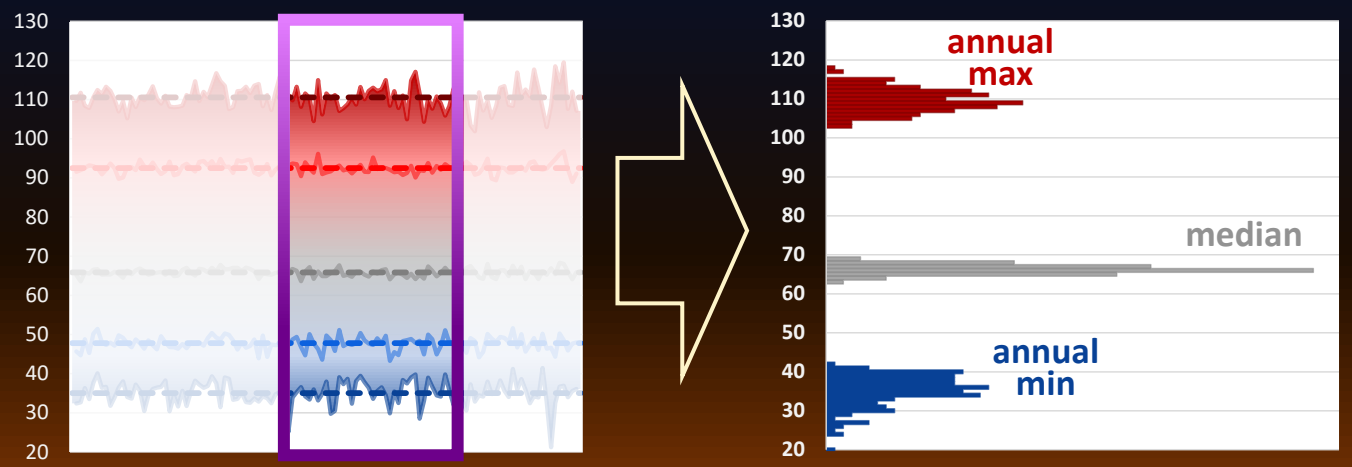

**Frequency Distribution**
Multiple Climate Models




- De-trending by temperature level (quantile) recognizes that anticipated climate change effects are not uniform
- Hourly chronological order is maintained to preserve inter- and intra-daily autocorrelations important for demand forecasting
- A rolling window avoids potential use of weather patterns from distant past/future that may not be applicable for the forecast year

# De-trending for future years



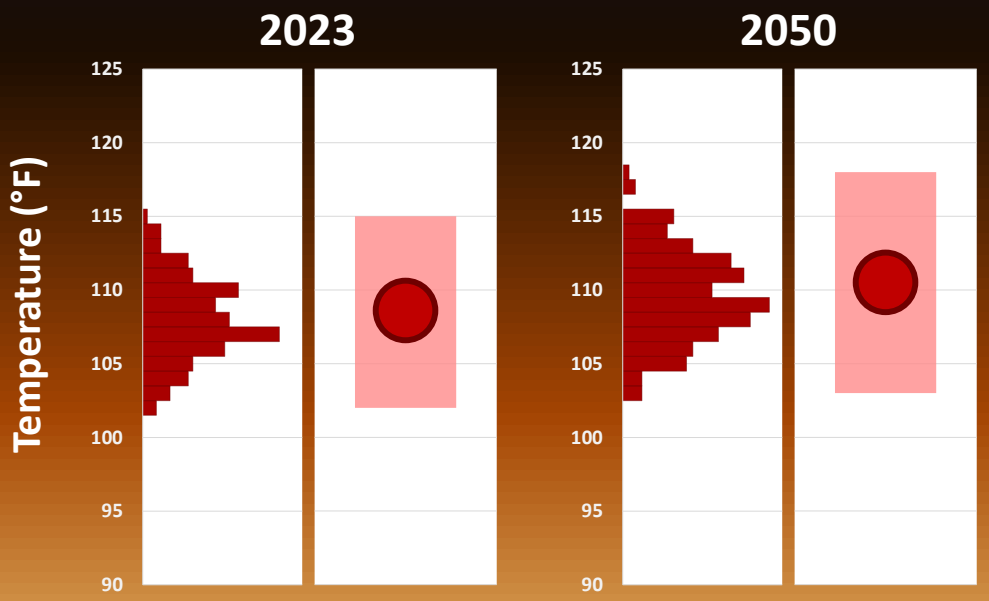

- Center of the rolling 30- to 50-year window used to develop weather variants shifts with the forecast year
- Expectations for each temperature level moves along the long-term trendline (shown in dashes)
- Variability around that expectation also changes as new future years are considered and past years are gradually dropped

# Changes in distribution of temperatures

*Distribution of potential outcomes influenced by both upward trends and increased variability in projected temperatures. Different effects on normal (e.g., 1-in-2 years) and more extreme (e.g., 1-in-10 years) conditions.*

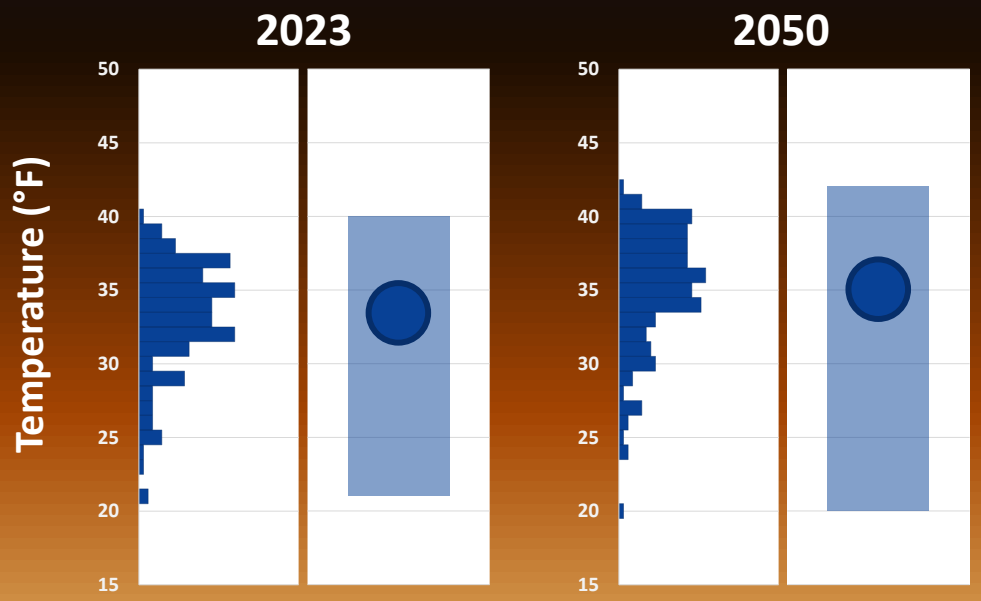
## Annual Maximum Temperatures

Example: Riverside Station




## Annual Minimum Temperatures

Example: Riverside Station



# Thank you

Learn more about WARP to Resilience and join our mailing list for study updates

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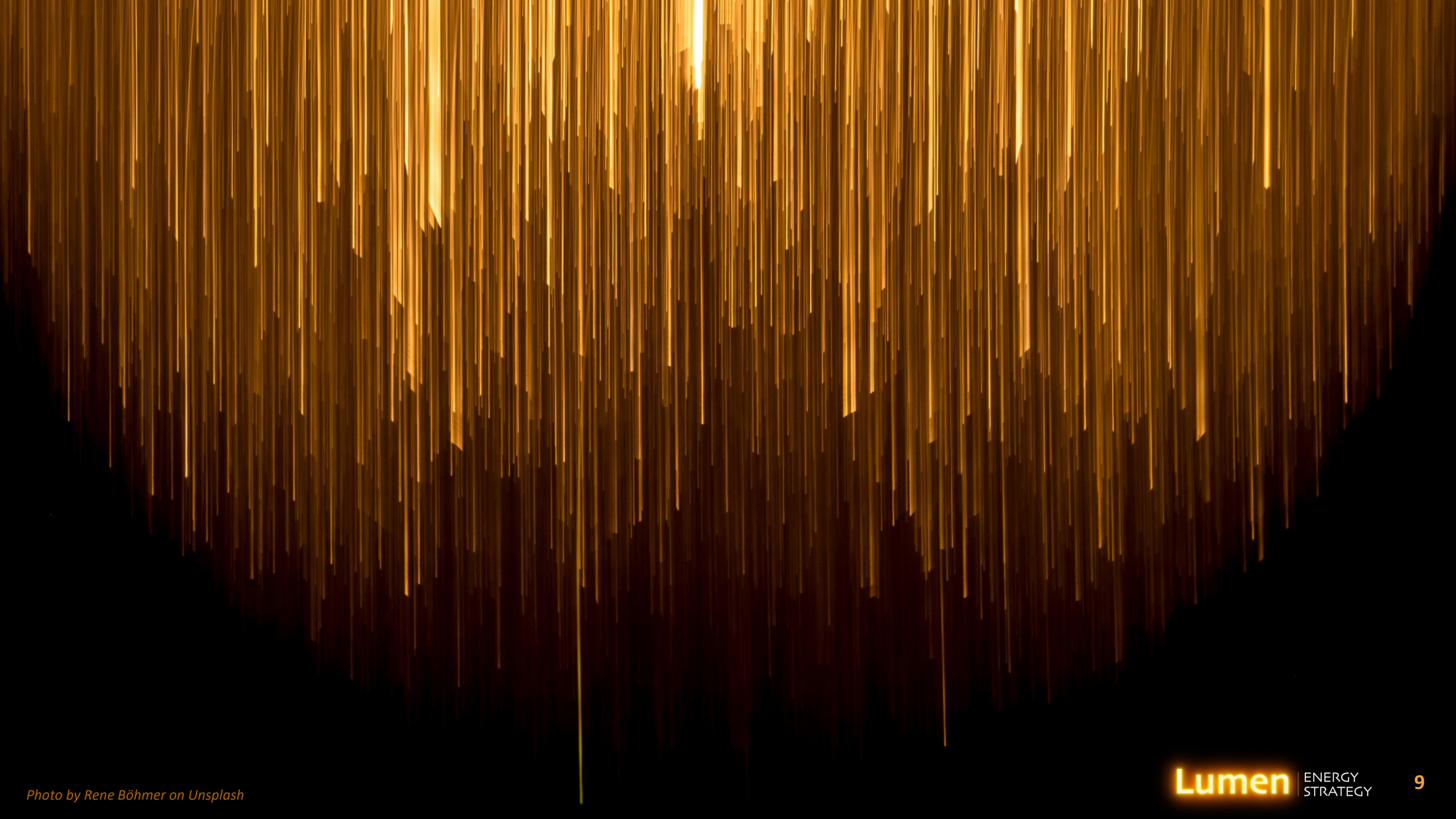

*Photo by Rene Böhmer on Unsplash*