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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

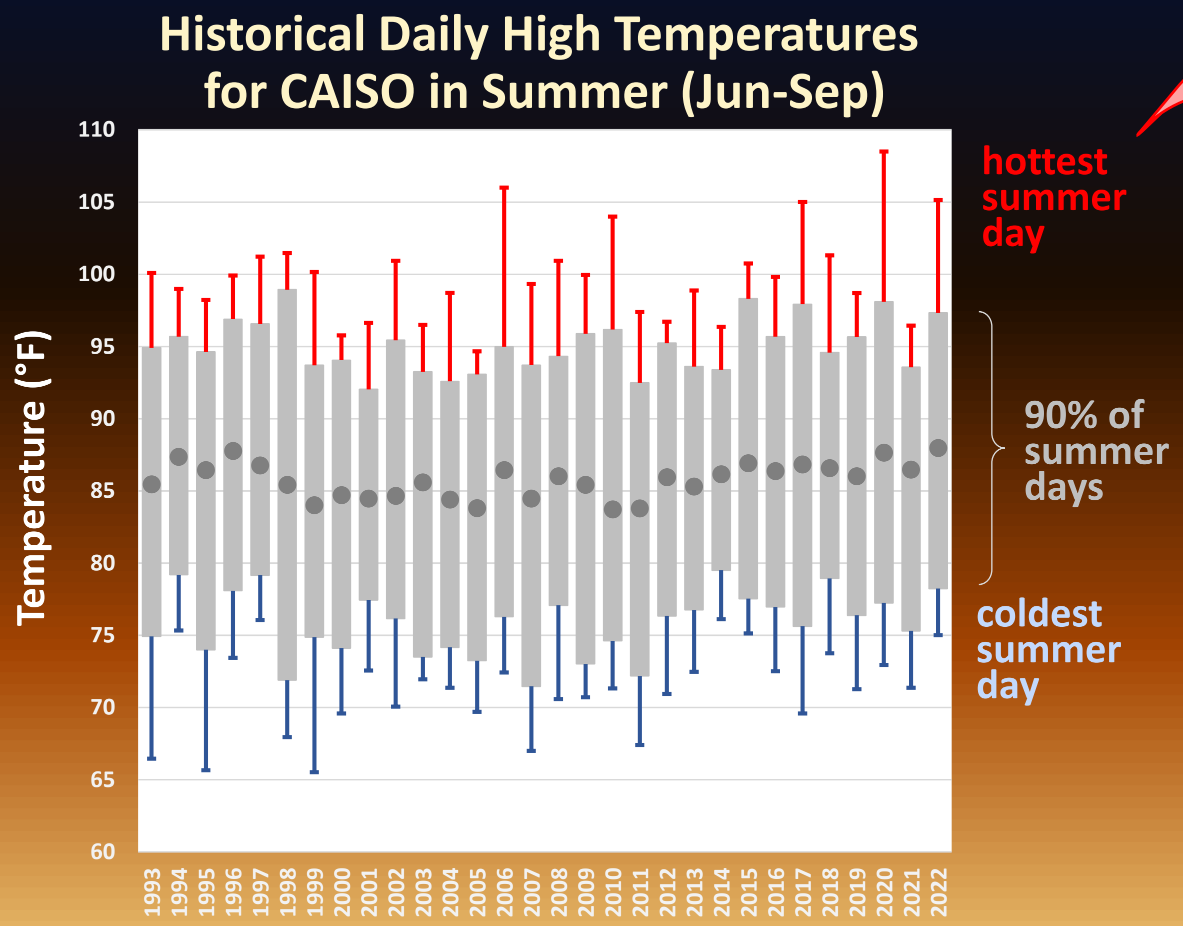
Lumen ENERGY STRATEGY

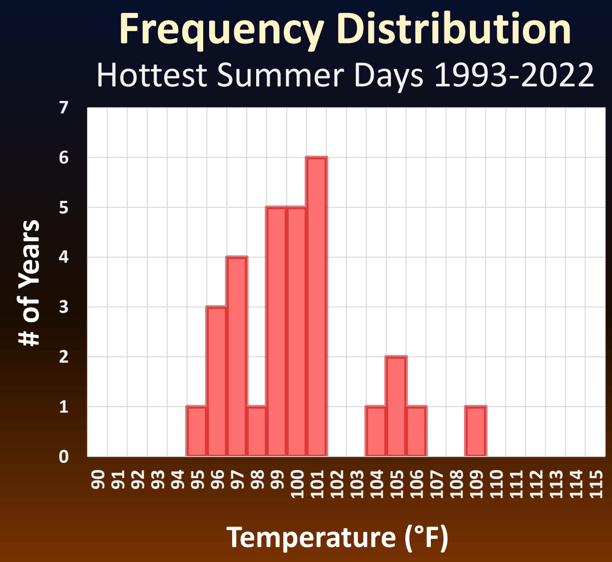
Need for future weather variants

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



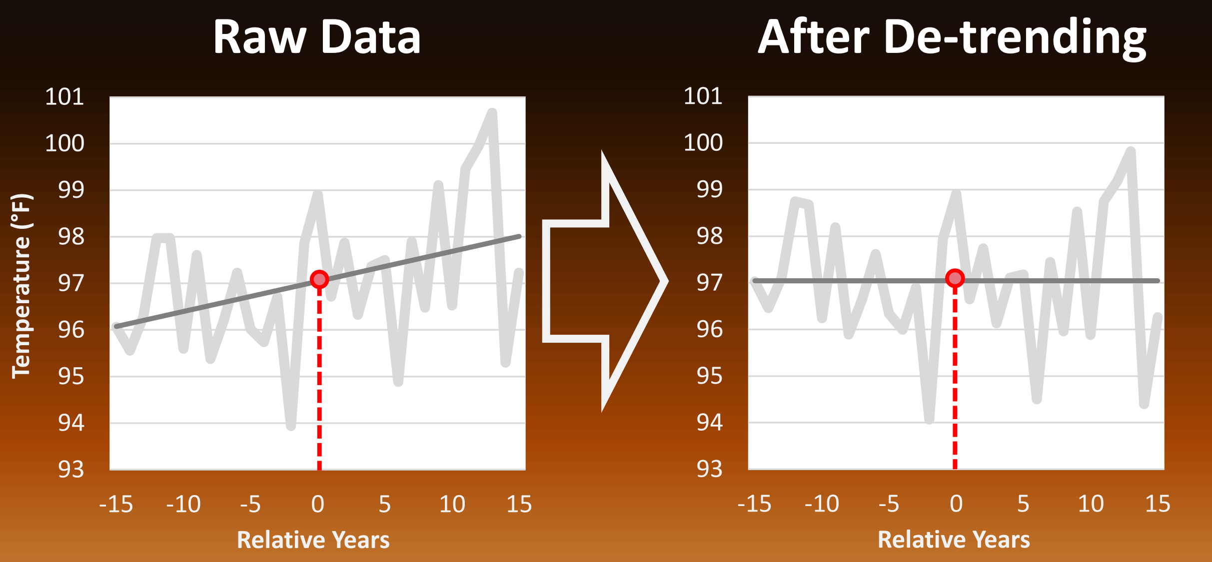


- Historical record is powerful and mostly indisputable (excluding measurement errors); but it represents just one realization of potential outcomes
- Statistical techniques can "fit" a distribution, but won't capture emerging, novel weather patterns related to climate change

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

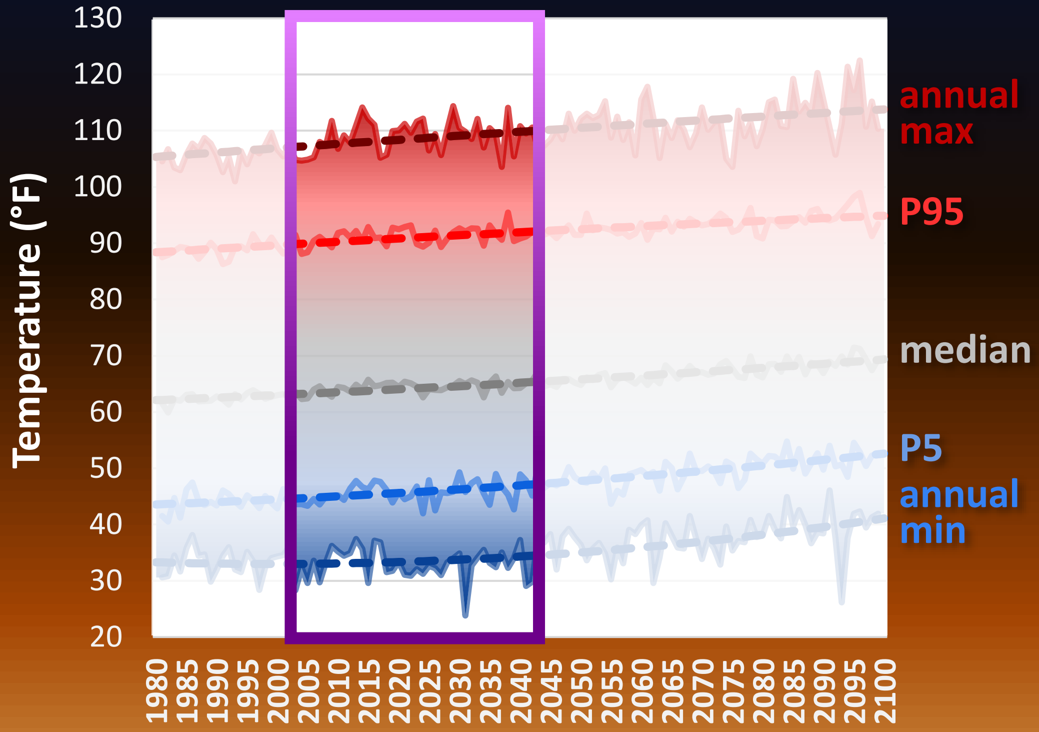
De-trending centers temperatures at 97°F as the level expected for forecast year

- 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

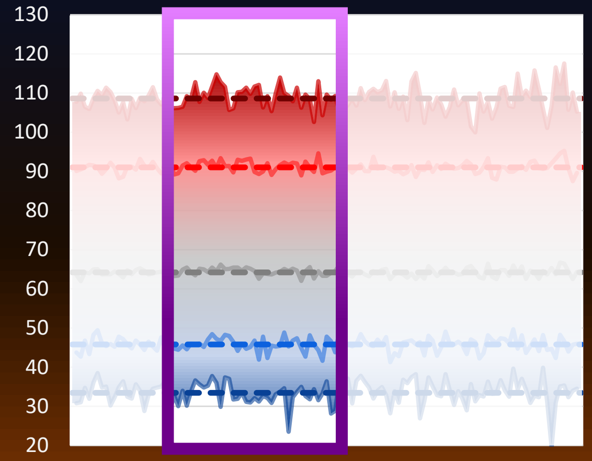
Historical & Projected Temperatures

Example: Riverside Station



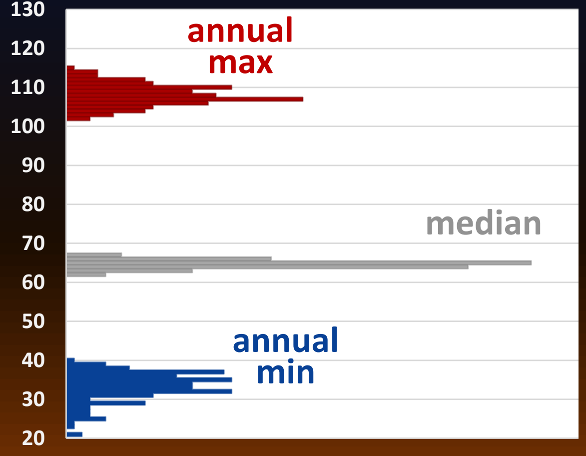
De-trended Temperatures

Base Year 2023



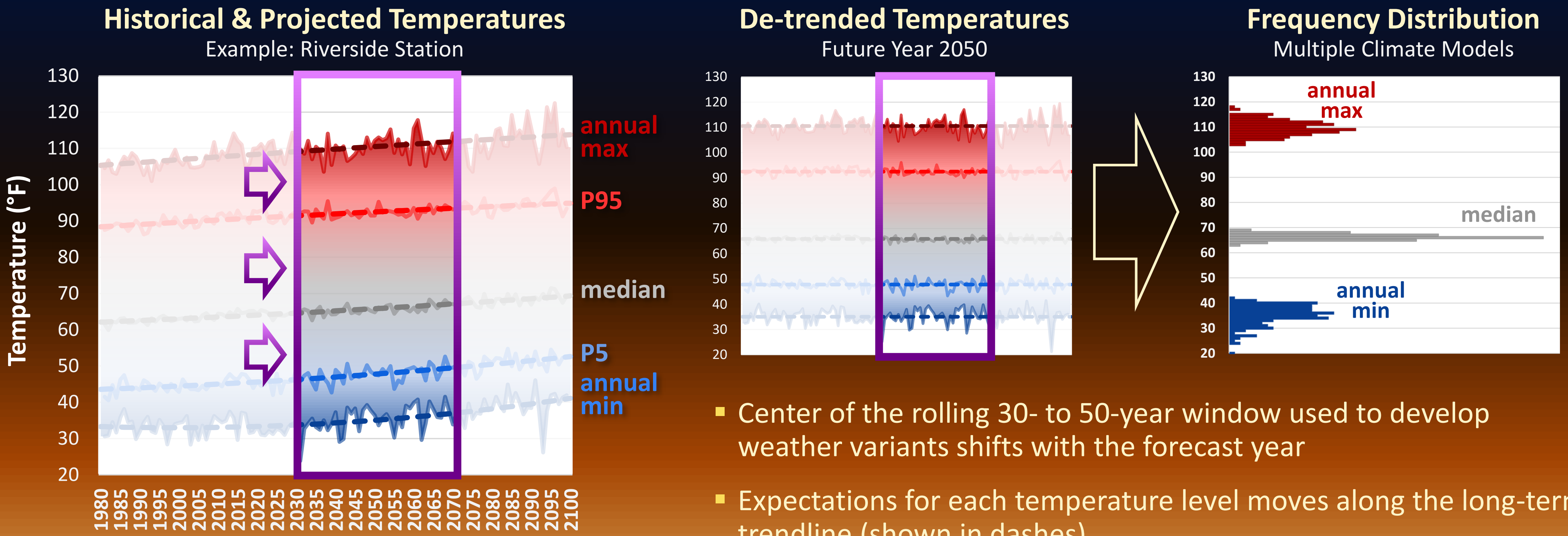
Frequency Distribution

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



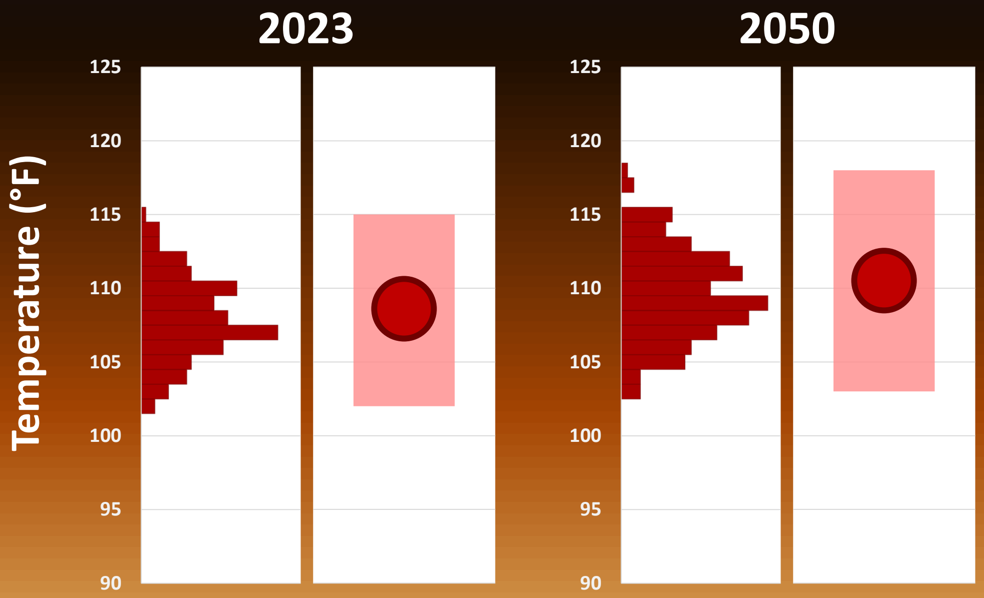
- Center of the rolling 30- to 50-year window used to develop weather variants shifts with the forecast year
- Expectations for each temperature level moves along the long-term trendline (shown in dashes)
- Variability around that expectation also changes as new future years are considered and past years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

Changes in distribution of temperatures

Distribution of potential outcomes influenced by both upward trends <u>and</u> 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.

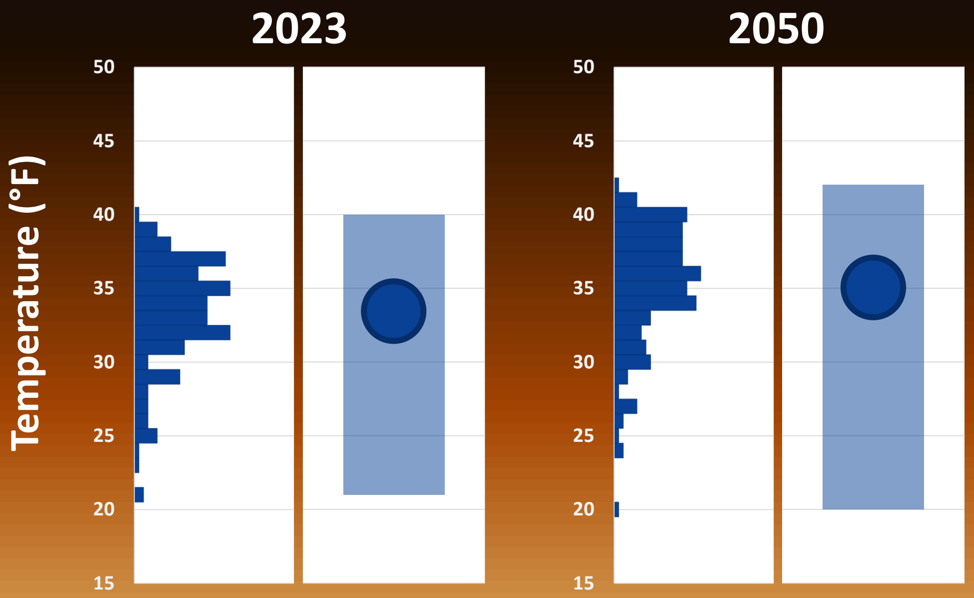
Annual Maximum Temperatures

Example: Riverside Station



Annual Minimum Temperatures

Example: Riverside Station



THANK YOU

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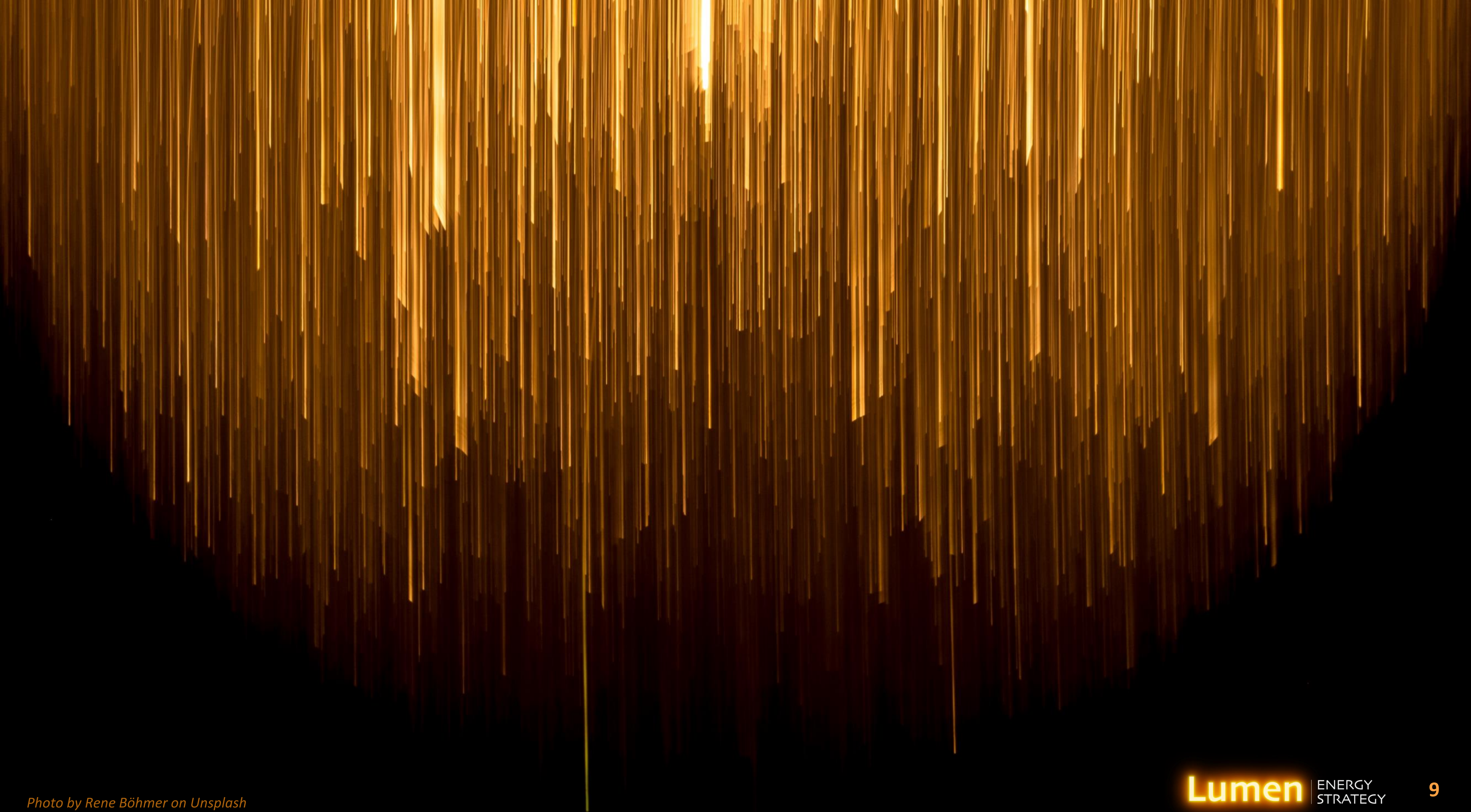

Photo by Rene Böhmer on Unsplash