



Development and Validation of a Xenon Arc Lamp Accelerated Aging Method for CSP Solar Mirrors

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Team:

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Key Technical Challenge

- Accelerated aging methods for CSP are not standardized
- New CSP low-cost mirrors entering the market
- Utilization of NREL's historical data

Project Goals

- Publication of XALE guidelines
- Publication of a Solar Mirror Materials Database

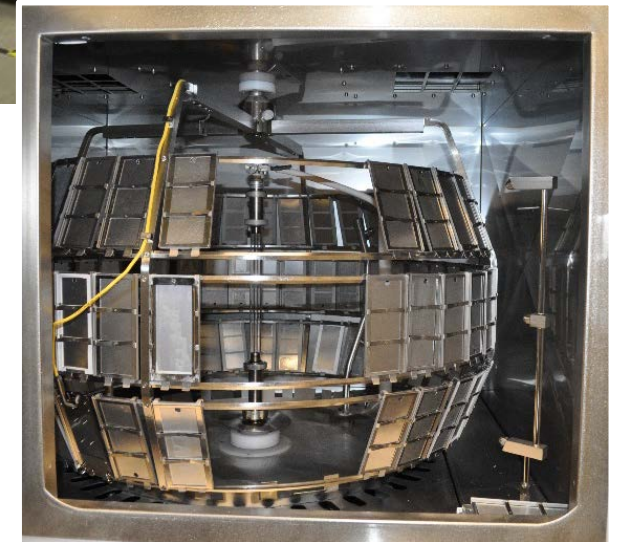


Accelerated Exposure Test (AET) Methods

Method	ISO	Condition	Duration
Neutral Salt Spray	9227	37°C, 100% RH [NaCl] = 5 g L ⁻¹ pH = [6.5 – 7.2]	480 hours
Copper-Accelerated Acetic Acid Salt Spray	9227	37°C, 100% RH [NaCl] = 5 g L ⁻¹ [CuCl ₂] = 0.26 g L ⁻¹ pH = [6.5 – 7.2]	120 hours
Condensation	6270-2	40°C, 100% RH	480 hours
Combined Thermal Cycling and Humidity		4 h: T = 85°C 4 h: T = -40°C 16 h: T = [40°C, 97% RH or 85°C, 85% RH]	10 cycles
UV + Humidity	16474-3	4 h: 60°C, 45 Wm ⁻² UV 4 h: 50°C, 100% RH	2000 hours

Xenon Arc Lamp Exposure (XALE)

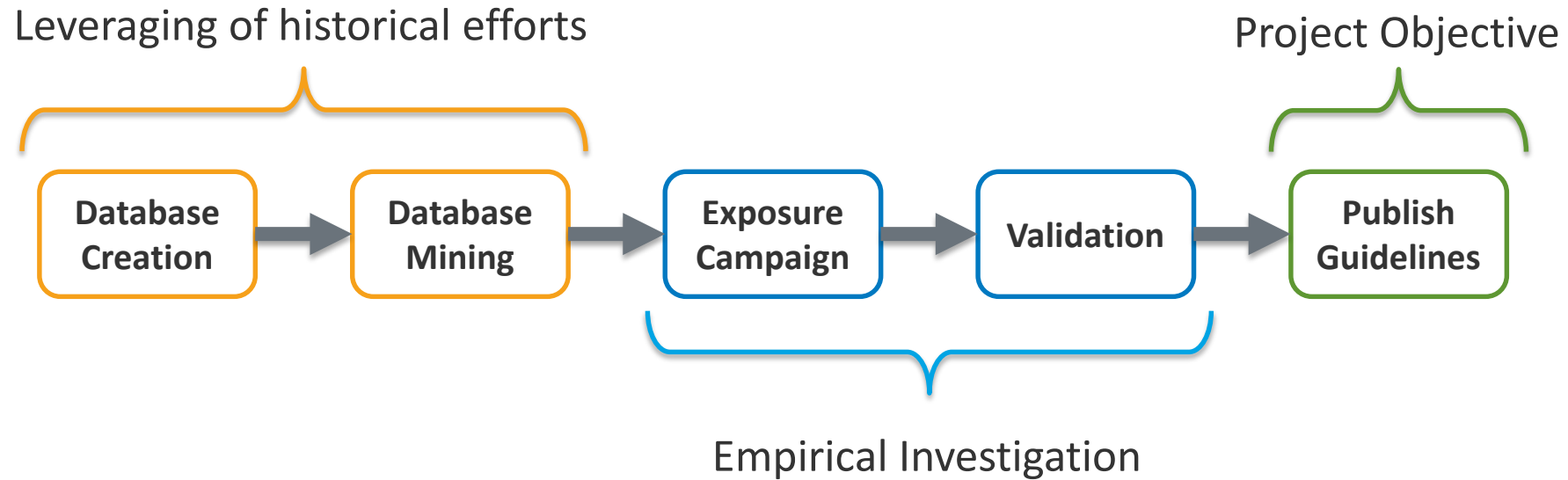
- Simulated terrestrial solar irradiance
- Temperature control
- Humidity control
- Front and back sample spray



XALE Standards

Standard	Title
ASTM G155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
ASTM E2141	Standard Test Method for Accelerated Aging of Electrochromic Devices in Sealed Insulating Glass Units
ASTM E3119	Standard Test Method for Accelerated Aging of Environmentally Controlled Dynamic Glazing
ASTM D7869	Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings
ISO 11341	Paints and varnishes -- Artificial weathering and exposure to artificial radiation -- Exposure to filtered xenon-arc radiation
ISO 16474-2	Paints and varnishes -- Methods of exposure to laboratory light sources -- Part 2: Xenon-arc lamps

Project Pathway

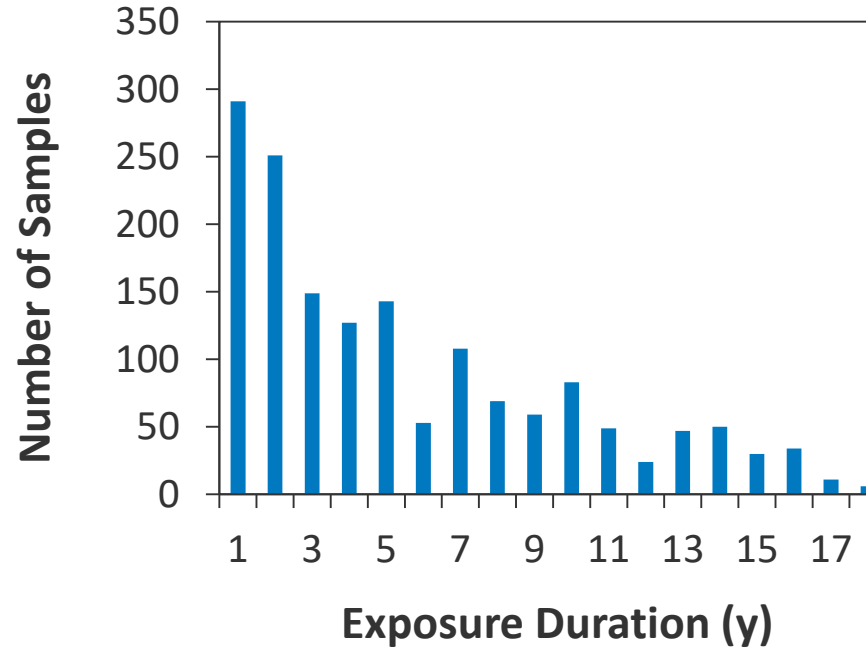


Project Pathway



NREL Materials Database

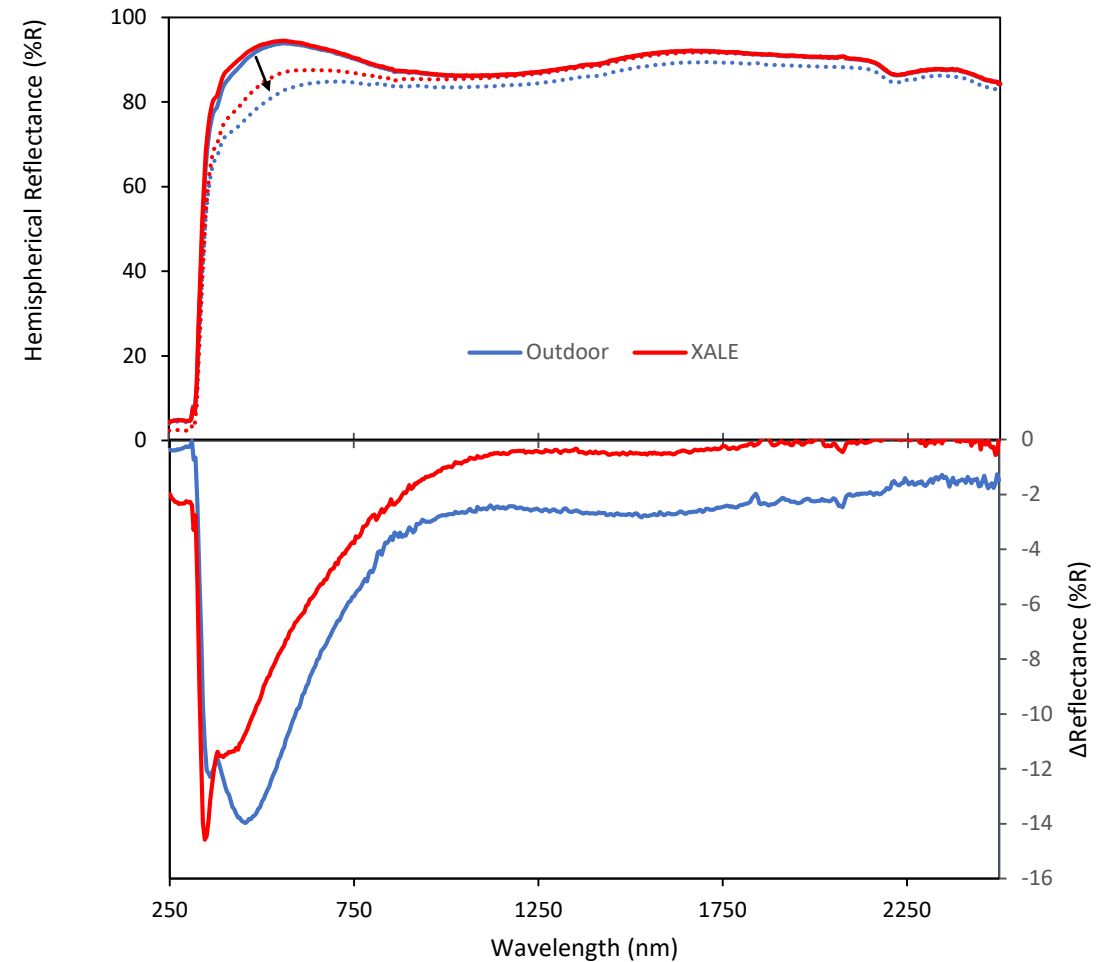
- 20 years of data
- 4,000 Samples
- 15 years of natural exposure
- 100,000 measurement points



Database Mining

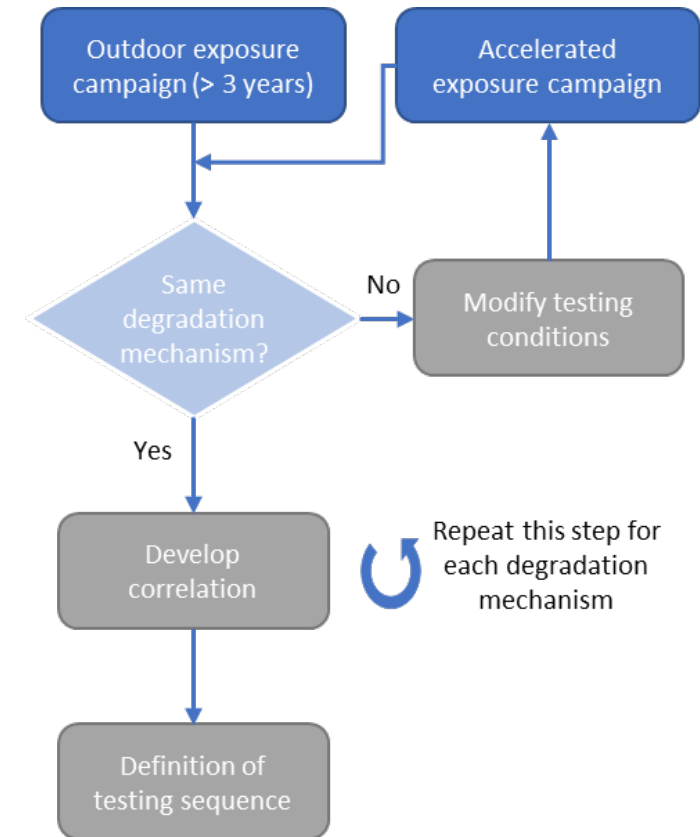
Machine Learning

- Algorithmic, iterative learning
- Modeling linear and non-linear relationships
- Computation without explicit programming



Exposure Campaign

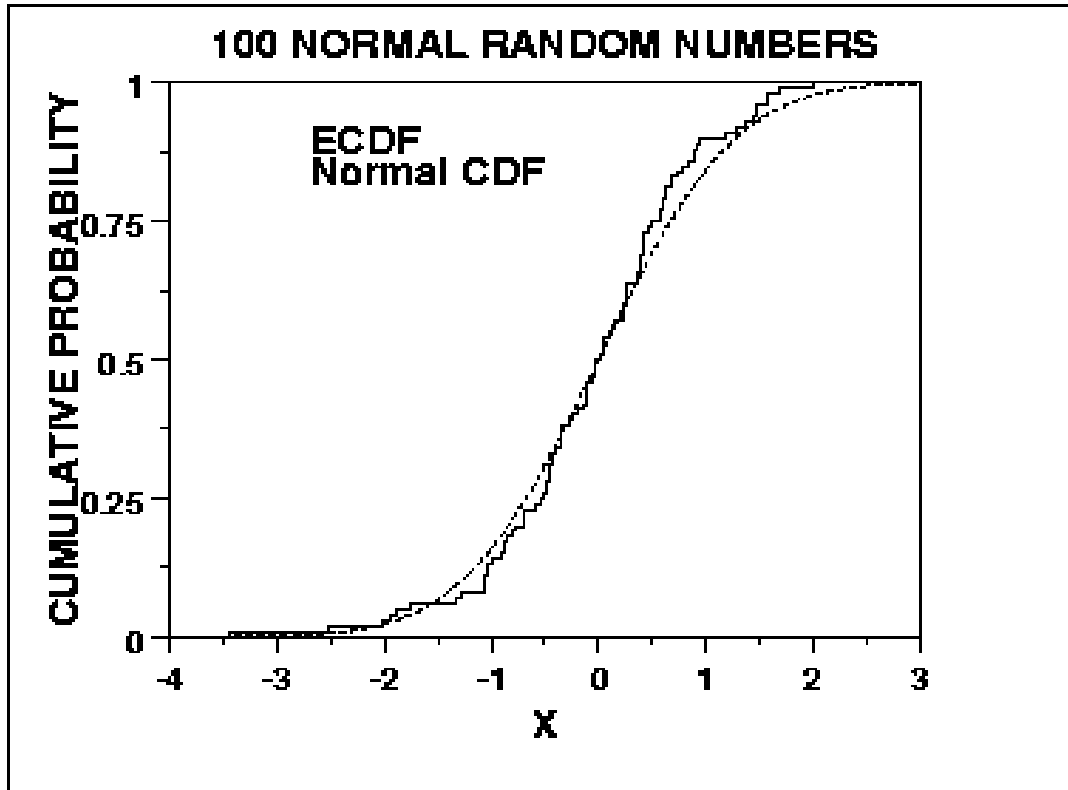
- Parameterize naturally occurring degradation mechanism
- Stress matching material in accelerated conditions
- Identify XALE conditions that excite singular degradation mode
- Derive correlation and determine acceleration factor



Sutter, F., A. Fernandez-Garcia., J. Wette, and F. Wiesinger. "Assessment of durability and accelerated aging methodology of solar reflectors." *The Performance of Concentrated Solar Power (CSP) Systems* (2017): 169-201.



Validation



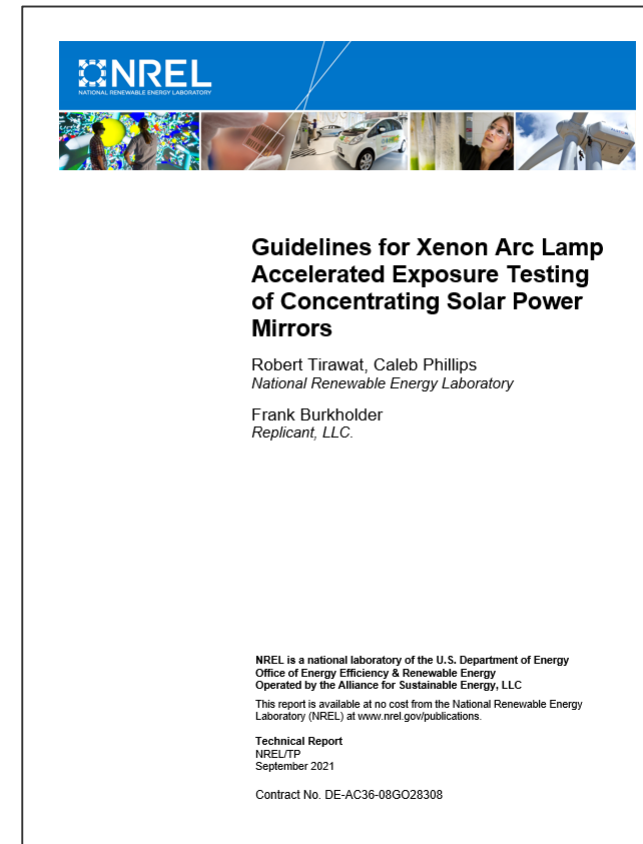
- Kolmogorov-Smirnov Test
- Principle Component Analysis
- Spearman's Correlation Coefficient

Image Source: NIST/SEMATECH e-Handbook of Statistical Methods,
<http://www.itl.nist.gov/div898/handbook/>



Guideline Publication

- Development of full standard
- Future validation



Team



Robert Tirawat, MS (NREL, CSP)

- Materials science
- Optical Characterization
- Accelerated aging



Dr. Frank Burkholder (Replicant, LLC.)

- Data warehousing ETL
- Cloud computing and web database deployment
- Deep learning



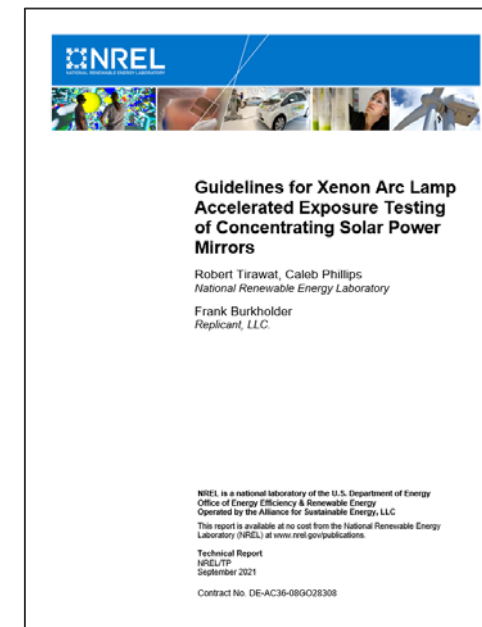
Dr. Caleb Phillips (NREL, Computational Sciences)

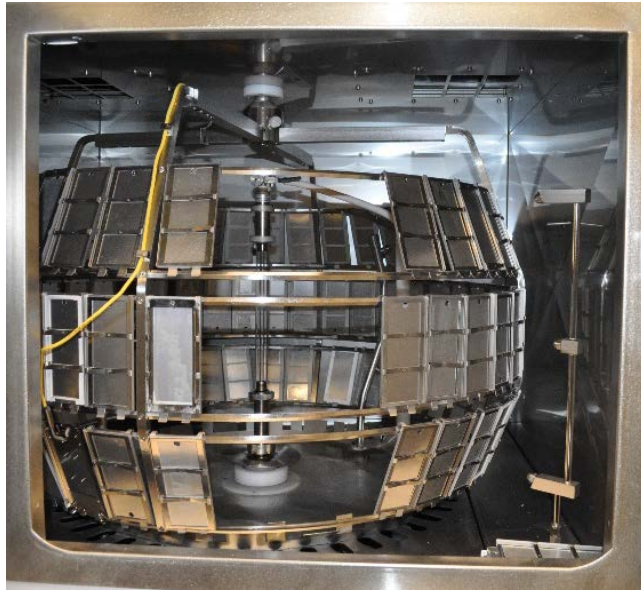
- Data analysis and visualization
- Machine Learning
- Statistical analysis

Project Summary

Development and validation of a XALE accelerated aging method for solar mirrors

- Release of a publicly available solar mirror materials database
 - Value gained from existing data
 - Potential for new relationships to be discovered
- Application of recent machine learning techniques in a new field
- Publication of XALE guidelines





Thank you!

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