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The New Era of Climate Change: Turn Risk into Opportunity

Paul S. Chinowsky, PhD and Jake Helman
Director and Lead Technical Engineer, Resilient Analytics
Outline

• Introductions
• Why is Climate a Concern?
• Understanding Climate Limitations
• 4 Levels of Engineering Opportunities
• Where to Start
Who is Resilient Analytics?

- Research and consulting in financial climate impact analysis since 2006
  - Data driven decision support for resilient infrastructure
  - Based engineering design
  - Adapt versus react financial impact
  - Full spectrum of assets

- 2006
- 2016
- 2022
- Stanley Consultants acquisition
- RA incorporated
  - International (WB, UNI, National (EPA), Local (Counties and Cities), and Private Clients
  - 50 peer-reviewed publications
  - Multiple peer-reviewed committees

www.resilient-analytics.com
Climate Impacts are Happening Now

U.S. 2022 Billion-Dollar Weather and Climate Disasters

- North Central Severe Weather May 11–12
- Central Severe Weather June 7–8
- Western/Central Drought and Heat Wave 2022
- Western Wildfires Spring–Fall
- Southern and Central Severe Weather May 1–3
- Texas Hail Storms February 21–22
- Southern Severe Weather April 11–13
- Southern Tornado Outbreak March 30
- North Central Hail Storms May 9
- North Central Hail Storms May 19
- North Central and Eastern Severe Weather July 22–24
- Central and Eastern Winter Storm and Cold Wave December 21–26
- Central Derecho June 13
- Kentucky and Missouri Flooding July 26–28
- Southeastern Tornado Outbreak April 4–6
- Hurricane Nicole November 10–11
- Hurricane Ian September 28–30
- Hurricane Fiona September 17–18

This map denotes the approximate location for each of the 18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.


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Climate Impacts are Happening Now

United States Billion-Dollar Disaster Events 1980-2022 (CPI-Adjusted)

- Drought Count
- Flooding Count
- Freeze Count
- Severe Storm Count
- Tropical Cyclone Count
- Wildfire Count
- Winter Storm Count
- Combined Disaster Cost
- Costs 95% CI
- 5-Year Avg Costs

Climate Impact on Engineering

Wastewater Treatment
- Extreme precipitation events can cause higher inflows and more frequent bypassing
- Sea level rise could impact outfalls

Air Pollution Management
- Higher summer temperatures can increase ozone concentrations
- Wildfires produce harmful PM

Erosion
- Soil erosion can be exacerbated by extreme precipitation events, drought, and heat waves
- Sea level rise can change soil in coastal areas and bring contaminants, including salt

Water Supply & Treatment
- Drought and reduced runoff can decrease water supply
- Increased water temperatures can reduce drinking water quality
- Extreme precipitation events can compromise drinking water resources

Land Resources
- Drought can have dramatic impact on food production and increase the need for irrigation
- Changes in climate will shift land use practices
Market Drivers and Opportunity

- Climate change is no longer an abstract concept, but rather a concern that is appearing in RFPs, developer discussions and investment decisions.

- Engineers need to be prepared for this and it needs to be done correctly.

- Many engineering firms choose to avoid climate change risks until they become the new standard. However, there is an opportunity to become a trusted partner with owners who understand climate risks and are ready to implement this new risk metric.
Climate in Engineering Design

- Climate has always been a factor in engineering design
  - Wastewater treatment inflow
    - 5- and 25-year 60-minute precipitation
  - Retention pond
    - System should be designed for the maximum wet year and minimum evapotranspiration year of record
- Why are we designing the infrastructure of the future to past climate conditions?
  - Historically that is the only data we had to go off
- Climate modeling changes that narrative
- We now have the capability to design the infrastructure of the future to projected climate conditions
Climate Projection Overview

• There are many models of climate change and many emissions scenarios

• Each model is deterministic and has an individual approach to modeling all the different subsystems that make up the overall climate system

• This leads to variances in projections

• There is no single answer to the future environment
Climate Projection Overview

- Models are downscaled to provide more detailed projections
- The higher the resolution, the greater specificity for a project
- Not all models are available at a higher granularity
- Potential for unrealistic accuracy – be careful as an engineer!
Climate - Hazards

Augment base variables from datasets, with additional data required for client analysis.

**Base Variables**
- Humidity
- Precipitation
- Wind
- Temperature
- Solar Irradiance

**Derived Variables**
- Wildfire (KBDI)
- Drought (SPEI)
- Heat Index/Heat Wave
- Cooling/Energy Demand (CDD)
- Flood Events
- Sea Level Rise/Storm Surge
- Other

**Climate Variable Dataset**

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**Example of additional variable development to augment base climate variables:**

Determination of Extreme Heat Day (EHD) temperature threshold:

- Days in baseline period = 365 x 20 = 7,300 days
- Hottest 2% of days = 7,300 x 2% = 146 hottest days
- Threshold = average of 146 hottest days

Any additional days above this threshold indicate an increase in extreme heat days.
Where Do Climate Models Fit in Engineering?

Level 1: Awareness
What are the future climate conditions projected to be in specific geographic areas?

Level 2: Vulnerability
What specific assets are vulnerable to projected climate change impacts?

Level 3: Operational
What are the financial, social, and operational costs of climate change to assets in geographic areas of concern?

Level 4: Strategic
What are the financially appropriate actions that should be taken in the near- and long-term to mitigate climate change impacts including adaptations and prioritization?
Application of Climate Projections to Engineering

- Design Risk
- Acute Risk
- Operational Risk
- Adaptation
Case Study

Water utilities across the country will experience new and enhanced vulnerabilities due to future increases in **extreme heat events**. The Water Utility Climate Alliance (WUCA) and the Association of Metropolitan Water Agencies (AMWA) recognized these threats and sponsored a study to analyze the impact of such extreme temperature events on critical water utility physical infrastructure assets and personnel.
Operational Areas of Impact

- **Personnel**: health, safety, and productivity
- **Electrical Equipment**: degradation of lifespan
- **Cooling Costs**: cooling equipment energy usage
- **Facilities**: roof and parking lot degradation
Personnel

The projected heat index in many regions will place workers at high levels of risk if no adaptation measures are taken.

The number of hours where breaks will be required will increase significantly, resulting in costs that could reach six figures for many water utilities by 2030.

If no adaptation procedures are put in place, it is projected that workplace accidents could increase 8% by 2030 and 17% in some locations by 2070.
Electrical Equipment

The ambient operating temperature within which electrical equipment operates is a key factor in its lifespan. As ambient temperature increases the expected lifespan of the equipment decreases, and vice versa.

Motors, motor control centers (MCCs) and variable frequency drives (VFDs) were the primary focus of this study because of the critical role they play in water utility operation.

Case Study: Ambient space temperature profile for each facility illustrated by the number of hours per year that each facility’s ambient space temperature falls within the temperature bins shown. Outdoor air temperature given for reference. Total hours = 8,760 for each facility.
Electrical Equipment

The **ambient operating temperature** within which electrical equipment operates is a key factor in its lifespan. As ambient temperature increases the expected **lifespan of the equipment decreases**, and vice versa.

Motors, motor control centers (MCCs) and variable frequency drives (VFDs) were the primary focus of this study because of the critical role they play in water utility operation.
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<table>
<thead>
<tr>
<th>Change from Baseline Cost of Motor Replacements Over 20 Years</th>
<th>Per Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility 1</td>
<td>Facility 2</td>
</tr>
<tr>
<td>12 Hour</td>
<td></td>
</tr>
<tr>
<td>2030 RCP-4.5</td>
<td>$107,039</td>
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<tr>
<td>2030 RCP-8.5</td>
<td>$126,171</td>
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<tr>
<td>2050 RCP-4.5</td>
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<td>24 Hour</td>
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<tr>
<td>2070 RCP-8.5</td>
<td>$684,703</td>
</tr>
</tbody>
</table>

*Case Study: Change compared to baseline in the estimated cost of additional motor replacements over the 20-year analysis periods 2030 (2021-2040), 2050 (2041-2060) and 2070 (2061-2080). Values are reported per facility. *Values represent incremental cost per horsepower.
Cooling Demand and Facilities

Cooling costs are projected to increase by 4% to 5% by 2030, 9% to 13% by 2050 and 12% to 23% by 2070.

From 2021 to 2080, we estimate the average increase in cooling cost for the facilities included in this study to be between $2.6 million and $4.1 million.

Shorter lifespans for roofing systems and parking lot surfaces

We recommend these additional costs be considered in near- and long-term budget planning.
### Adaptation

**Personnel:** Worker scheduling, adopting new rest cycle standard, confined spaces

**Electrical Equipment:** Higher insulation temperature ratings, enhance maintenance schedules, have replacements on hand

**Cooling Costs:** Commissioning, envelope improvements, air-side economizer

**Facilities:** Cool roof coating, upgrade binder design temperature
BOULDER, COLORADO
Cost impacts from 2020 to 2050

- Wildfire area is projected to increase by 38%
- Road maintenance to double to $1,130 per mile per year
- Severity and length of droughts to increase
- $68 million for structural improvements to bridges
- $4.6 million in cooling center operating costs
- $19 million in adaptation costs for precipitation impact
- $16 million in investments to increase system capacity
- Increase in cooling costs of 54% to 75%
DATA CENTER RISK ANALYSIS

The data center risk analysis quantifies how climate change is projected to impact data centers across the US, with a specific focus on a facility in Santa Clara, CA. The analysis is broken up into three different categories: design risk, operational risk, and acute risk.

**Design Risk:** Represents the vulnerability of changes to building design standards, including HVAC.

**Operational risk:** Represents the vulnerability to changes in cooling energy and the amount of free cooling hours available at a location.

**Acute risk:** Represents the physical risks (flooding, wildfire, etc.) to the data center site and surrounding infrastructure.

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**Key Findings For All 10 Sites:**

**Design Risks**
- Extreme annual temperature is projected to increase for all locations by 0.9°F to 3.1°F by 2030 and 1.6°F to 5.1°F by 2050.
- 0.4% humidity ratio (grains of moisture/lb dry air) is projected to increase for all locations to 9.0% by 2050.

**Operational Risks**
- Cooling costs are projected to increase by 6% to 11% by 2030 and 13% to 24% by 2050.
- Total cooling costs are projected to increase by $3.5 to $6.6 million between 2020 to 2040.

**Acute Risks**
- 70% of locations are projected experience an increase in extreme precipitation events by 2030.
- 30% of locations are projected to experience 20 additional days of extreme wildfire risk days annually by 2030.
EPA NATIONAL CLIMATE IMPACTS STUDY
Risk factors for highways and bridges

No Adaptation

Reactive Adaptation

Proactive Adaptation

Change in Costs
(undiscounted, million $2018)
-17 - 0
>0 - 1
>1 - 5
>5 - 10
>10 - 50
>50 - 100
>100 - 1,000
>1,000 - 5,800
Adaptation Recommendations - The Climate Impact Analysis provides multiple standard and custom adaptation options to address multiple impact conditions
Cost-Benefit Analysis - The Climate Impact Analysis provides a cost-benefit analysis to assist in determining whether a business-as-usual approach or an adaptation approach should be preferred.
Where to Start

• Understand appropriate use of climate models
• Find the vulnerabilities of concern for clients
• Understand the potential for operational impacts
• Where is your strategic benefit?
Conclusion

• Climate has always been an input to design – now include future projections instead of just historic
• Climate considerations require more than just awareness
• Every location in the United States has some future climate impact
Questions?

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