When the Grid Goes Down

Saving Lives With Your Building's Envelope and Back-up Power

The death toll rose to 14 at a nursing home Hollywood, Florida due to a power outage caused by Hurricane Irma. Source: CNN

Building Energy 2019

Northeast Sustainable Energy Association

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Katie Courtney

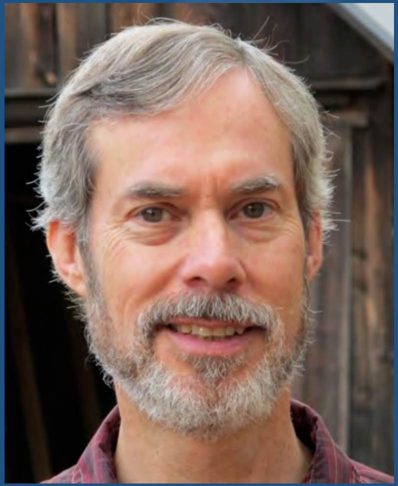
When the Grid Goes Down…

What we'll cover:

- The LEED pilot credits on resilience – how they work
- Credit on passive survivability and back-up power in more detail
- Modeling passive survivability for a hospital in Nantucket
- Interactive exercise to help you understand passive survivability and the pilot credits

Who We Are:

Jim Newman, Linnean Solutions

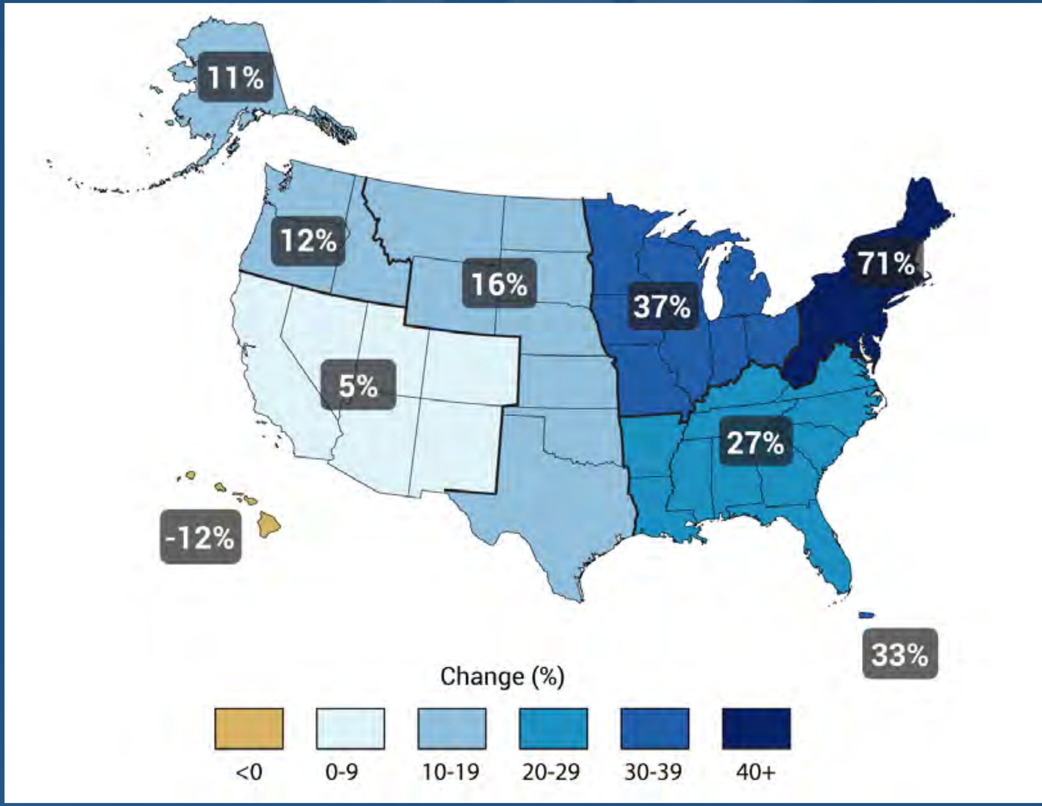


Alex Wilson, Resilient Design Inst. and BuildingGreen, Inc.

Katie Courtney, Cannon Design

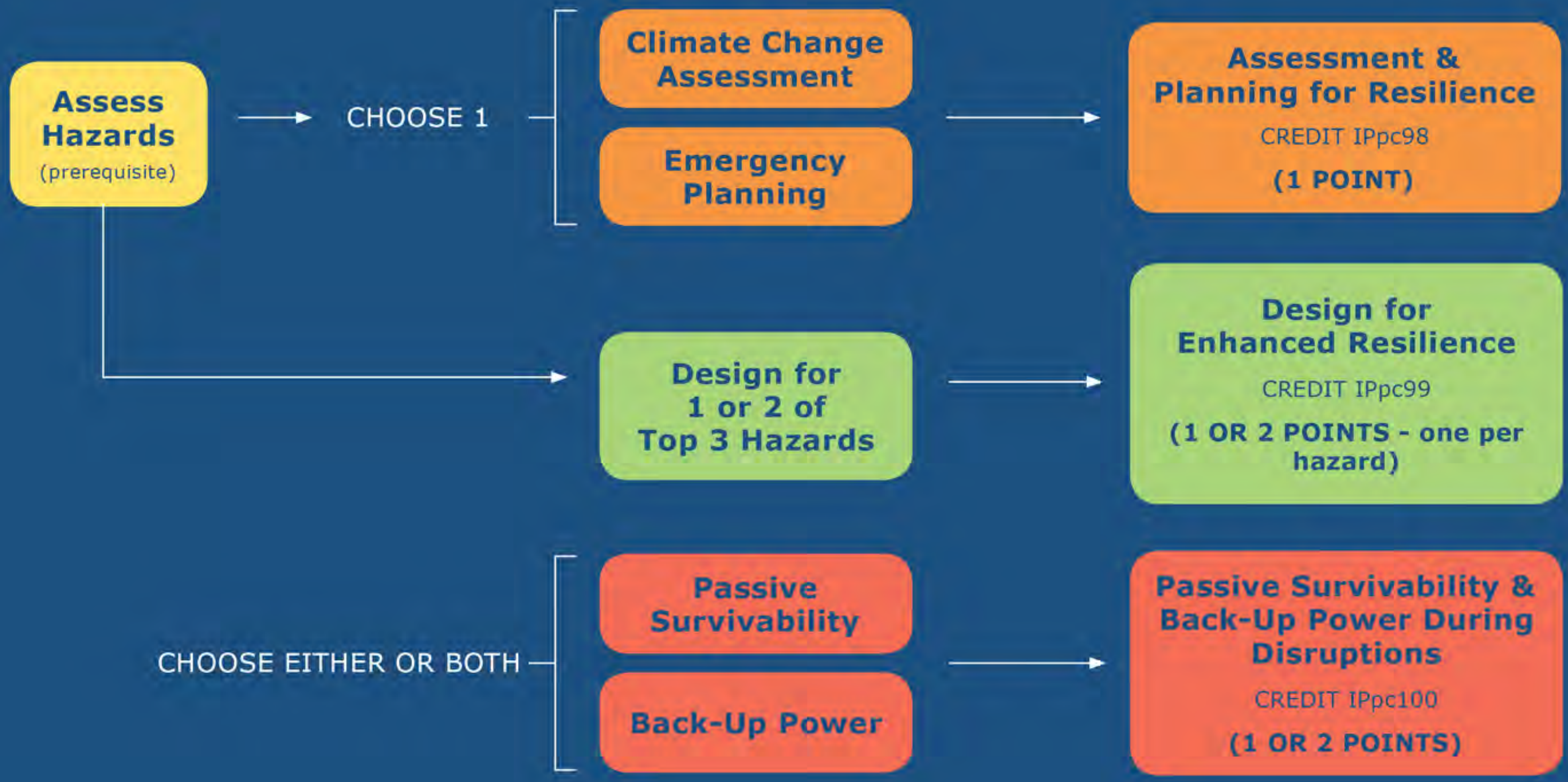
Power outages to become more frequent

- Climate change related:
  - More intense storms
  - Sea level rise
  - Coastal storm surge
  - Heat waves stressing electrical loads
  - Drought
  - Wildfire
- Non climate-change related
  - Earthquakes
  - Space weather
  - Equipment malfunctions
  - Terrorism



Percent increase in very heavy precipitation 1958-2012 (defined as the heaviest 1% of all events). Source: 2014 National Climate Assessment

Introducing the LEED pilot credits on Resilient Design



When the grid goes down

Option 1: Vulnerability Assessment and Planning

Hazard Identification and Analysis Worksheet for Amherst

Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Vulnerability
Floods (100-year)	Large	Low	Limited	2 – High risk
Flooding (localized)	Medium	High	Minor	1 – Highest Risk
Severe snow/ Ice storms	Large	Very High	Limited	1 – Highest risk
Hurricanes	Large	Low	Critical	3 – Medium risk

Option 1: Emergency Plan

Red Cross
Ready Rating
Program
American Red Cross

Sample Assessment Questions
Businesses and Organizations

3. Plan - Develop an emergency response plan.

3.1 We have a plan in place designed to protect our business or organization and employees before, during and after an emergency or disaster. We have completed the following activities as part of our emergency response planning:

3.2 We have a written plan describing how our business or organization will respond during a disaster or medical emergency. This plan includes the following components:

D. Procedures for communicating with employees, families, clients, emergency response organizations, media representatives and other stakeholders prior to, during and after a disaster or medical

When the grid goes down

Design for Enhanced Resilience

Address the vulnerabilities identified in IPpc98

Follow specific recommendations for mitigating the identified vulnerabilities

Example:

Flooding

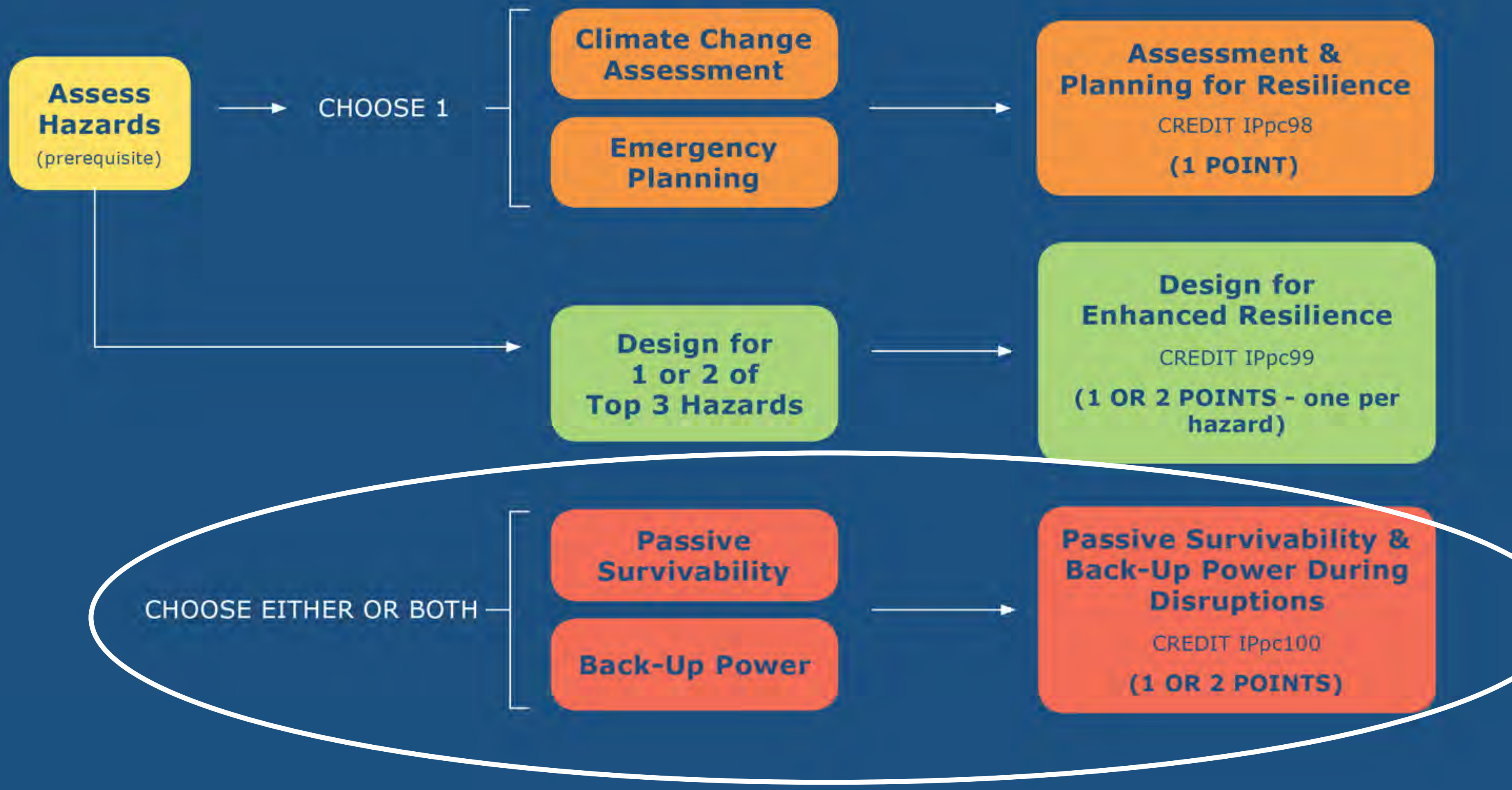
Option 1: Flooding-Specific design measures

RELi V2.0 Standards

Option 2: Flooding-Specific design measures

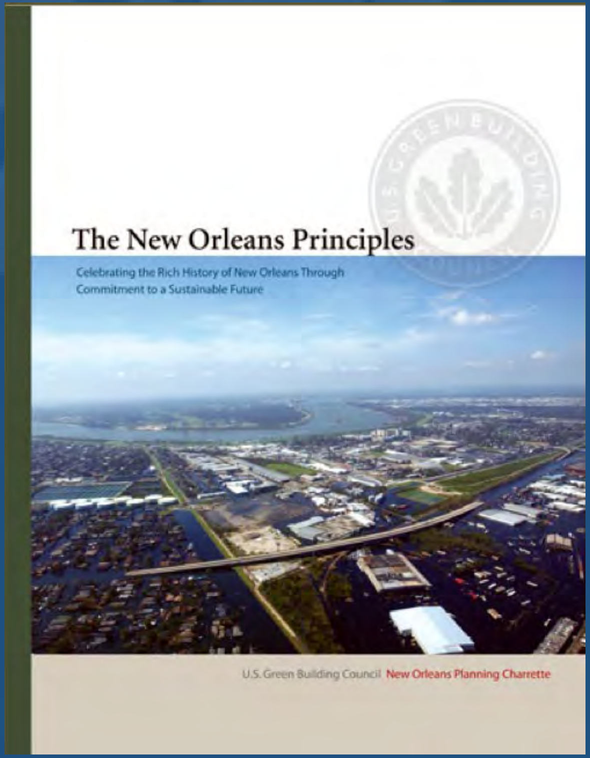
Meet Executive Order (EO) 13690 Federal Flood Risk Management Standard. But flood elevation must be at least 3 feet (1 meter) above the known Base Flood Elevation (100 year level flood).

Credit 100 – Providing for Passive Survivability and Back-Up Power During Disruptions



Introducing "passive survivability"

Charrette on Gulf Coast reconstruction in the fall of 2005—
introducing "Passive Survivability. Photo: Alex Wilson



The New Orleans Principles

8 · *Provide for passive survivability*

Homes, schools, public buildings, and neighborhoods should be designed and built or rebuilt to serve as livable refuges in the event of crisis or breakdown of energy, water, and sewer systems.

Addressing passive survivability

BR 6

Analyze Strategies to Maintain Habitability During Power Outages

Issue:
Research on climate change indicates that there will be an increase in the frequency and severity of events that can disrupt the city's power, water, sewer and transportation infrastructure. In the event that city services are not usable, passive and dual-mode functions will be critical.

Recommendation:
Undertake a comprehensive study of passive survivability and dual-mode functionality, then propose code changes to incorporate these concepts into the city's building codes. Also include a study on refuge areas in sealed buildings.

Benefits	Costs
N/A Savings	N/A Cost
Health & Safety	
Environment	

New York City – Greening the Codes Task Force Report - 2010

Addressing passive survivability

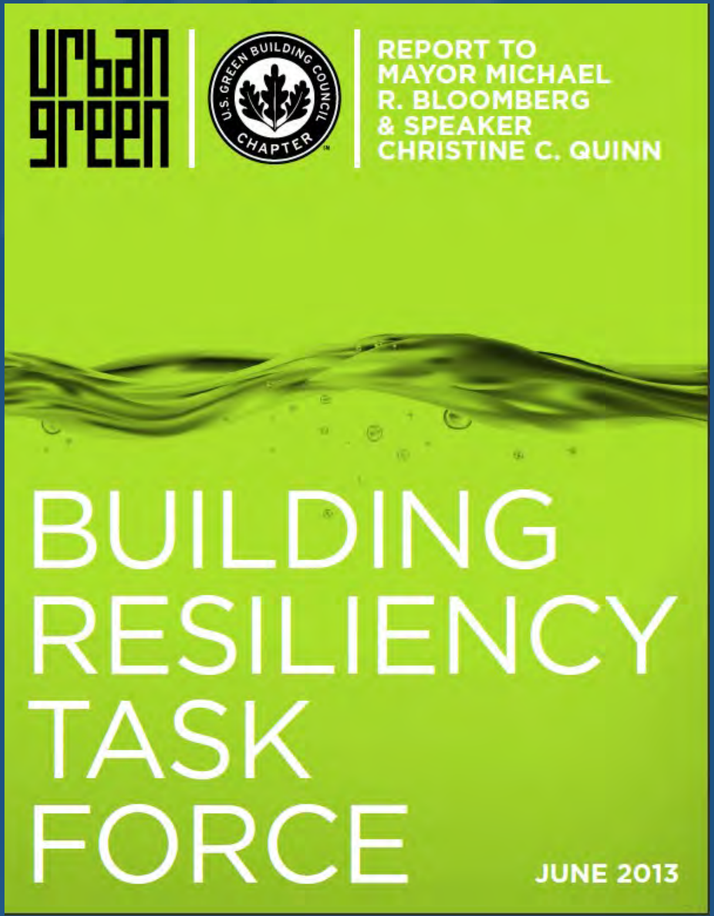
27 Maintain Habitable Temperatures Without Power

Issue: Utility failures often disable heating and cooling systems, leaving interior building temperatures dependent on whatever protection is provided by the insulation and air sealing of a building's walls, windows, and roof.

Recommendation: Extend the mandate of the Task Force through Fall 2013 to develop a multiyear strategy for ensuring that new and substantially altered buildings maintain habitable temperatures during utility failures. Clarify requirements for tightly sealing new windows and doors and upgrading roof insulation during roof replacement.

✚ further action

Recommendation from the Building Resiliency Task Force



Building Resiliency Task Force in New York City – Final Report, June, 2013

Addressing passive survivability

May 2013 RDI charrette in NYC on metrics of passive survivability. Photo: Alex Wilson

BRI BUILDING RESEARCH & INFORMATION 2016
Vol. 44, No. 1, 1–19, http://dx.doi.org/10.1080/09613218.2015.1033875

INFORMATION PAPER

Overheating and passive habitability: indoor health and heat indices

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E-mail: alex@resilientdesign.org

As extreme heat and weather events are predicted to increase due to global warming, the risk of human heat stress within buildings will increase. To be resilient, buildings will need the capacity to provide habitable indoor conditions without power for limited amounts of time. Additional indoor thermal standards are required for public health to address 'passive habitability' during power outages. Current research on building-related heat stress and numerous heat indices is examined in relation to the development of a new heat-safety metric for use in passively conditioned buildings. Most indoor overheating research relies on outdoor temperature data and has no common indoor heat index for evaluating indoor heat stress. A recommendation is made for using the wet-bulb globe temperature (WBGT) and predicted heat strain (PHS) indices for modelling and monitoring of indoor heat stress in healthy adult populations because both indices utilize the primary thermoregulation variables, have associated heat-stress thresholds, and can be assessed or tracked with existing environmental monitoring methods and predictive energy modelling techniques. Further research is recommended on health effects and exposure limits of vulnerable populations, and the variation in thermal factors within buildings and the building stock.

Habitability isn't just about temperature

NOAA's National Weather Service

Heat Index

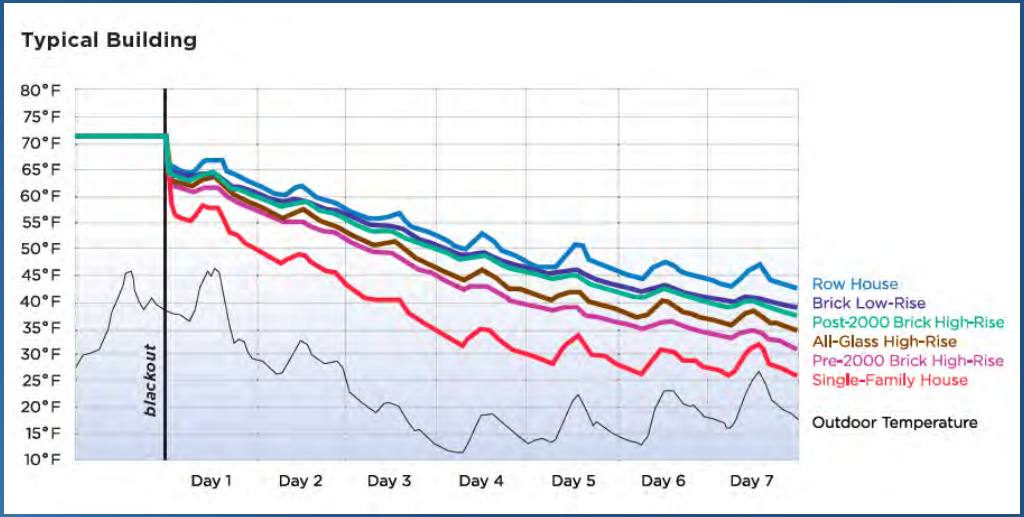
Temperature (°F)

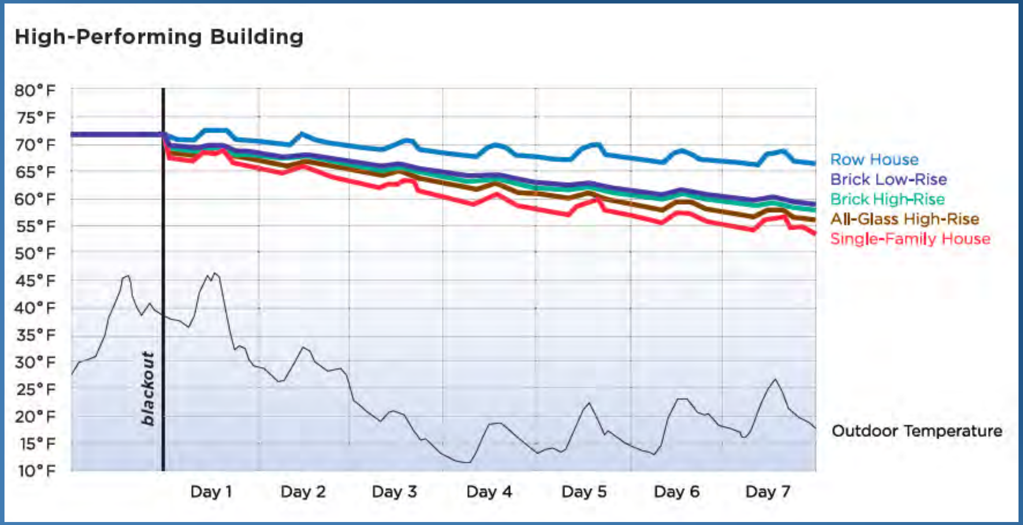
Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Better insulated buildings keep us safer





Baby It's Cold Inside report from Urban Green - June, 2013

LEED Pilot Credit: Passive Survivability

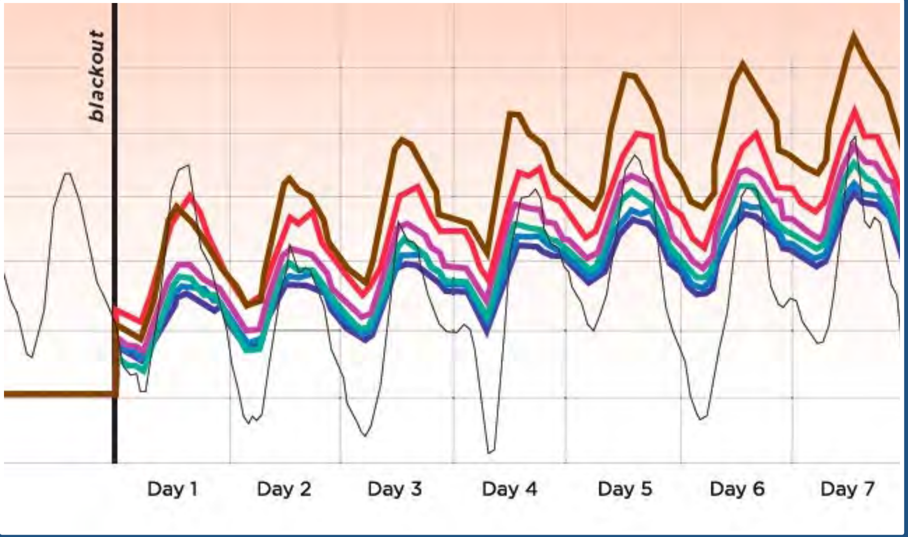
Requirements:

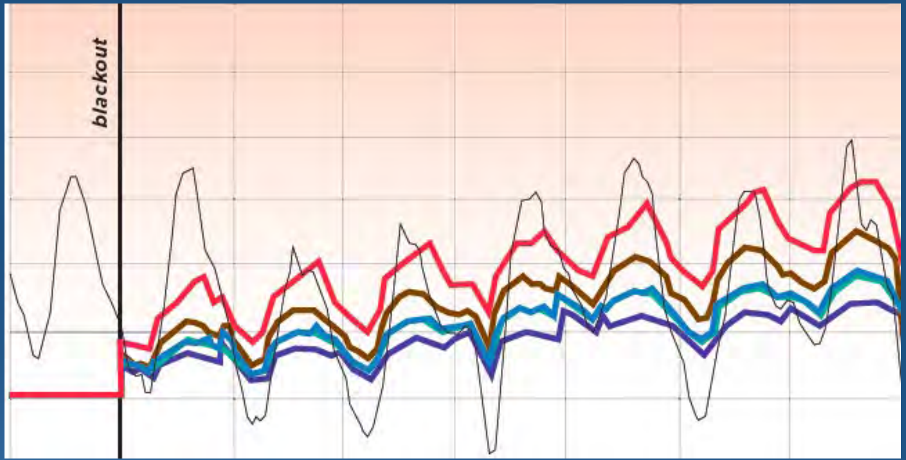
- Demonstrate that a building will passively maintain “habitable temperatures” during a power outage that lasts 4 days during peak summertime and wintertime conditions of a typical year.

Operable windows at Spaulding Rehab Hospital in Charlestown, Boston. Photo: Anton Grassl/Esto, Courtesy of Perkins+Will

LEED Pilot Credit 100: Thermal Habitability

- Three methodologies for demonstrating compliance
  1. Psychrometry (WBGT or Heat Index)
  2. SET methodology
  3. Passive House certification





Temperature fluctuations during power outage in NYC. Graph: Urban Green Report: "Baby It's Cold Inside"

SET Methodology for compliance

Requirements:

- Demonstrate through thermal modeling that a building will passively maintain “habitable temperatures” during a power outage that lasts 4 days during peak summertime and wintertime conditions of a typical year.

Key Definitions:

- Standard Effective Temperature (SET) factors in relative humidity and mean radiant temperature
- Habitable Zones: Defined by team
- Occupant Density: necessary to accommodate the total building population in the habitable zones.
- Ventilation: All habitable zones must have access to natural ventilation

Livable temperature:

- Cooling: Not to exceed 9 °F SET-days (216 °F SET-hours) above 86°F SET for residential buildings.
- Cooling Not to exceed 18 °F SET-days (432°F SET-hours) above 86°F SET for non-residential buildings.
- Heating: Not to exceed 9 °F SET-days (216 °F SET-hours) below 54° SET for all buildings.

Passive House certification for compliance

Passive House-certified Levy residence (built of AAC) in Woodstock, NY - photo: Alex Wilson

- The Int'l Passive House standard and the U.S. adaptation of that standard are good indicators of passive survivability
- Thus, Passive House certification is accepted as an alternative compliance path for passive survivability in the LEED pilot credits
- With natural ventilation

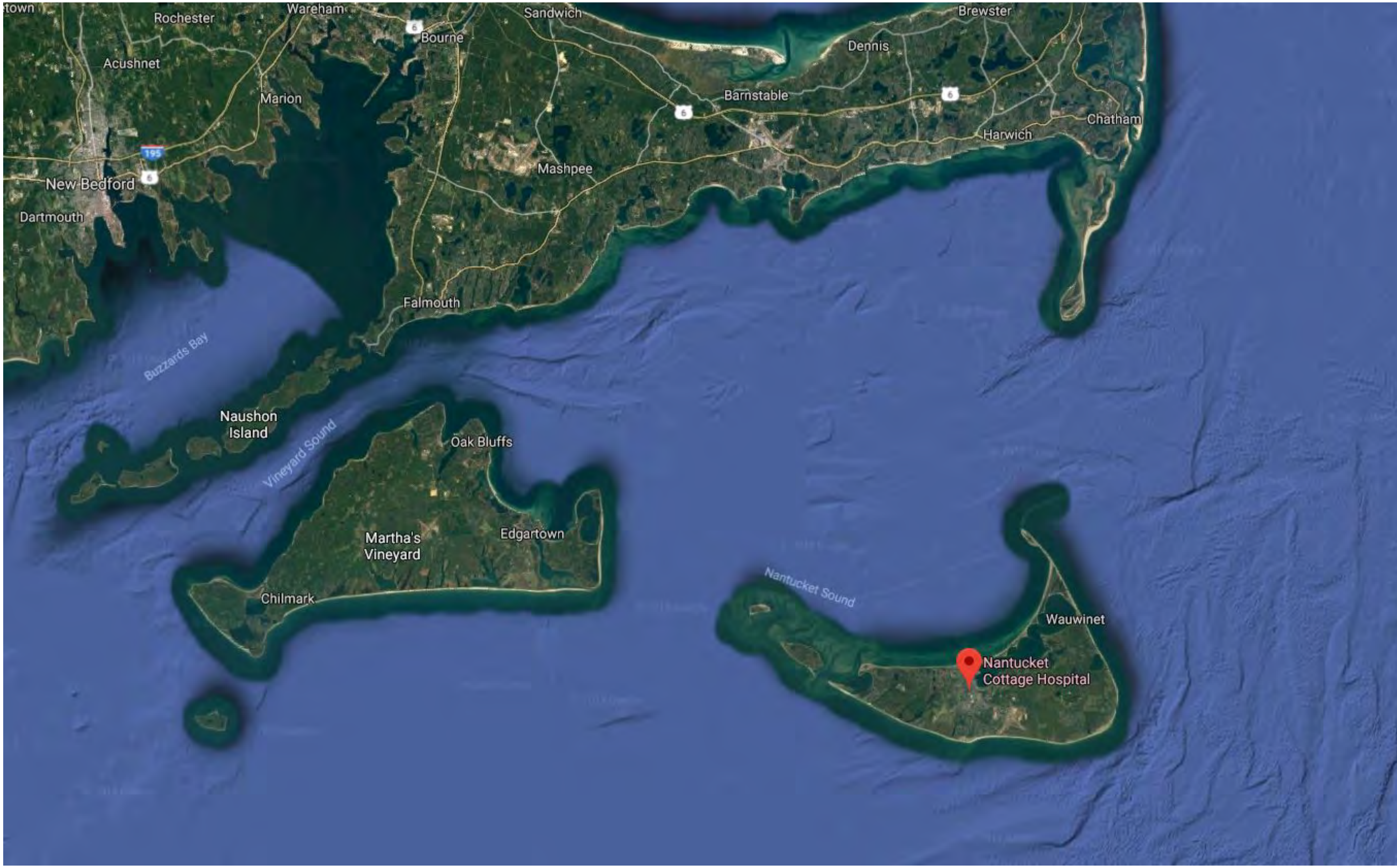
Back-Up Power – 2 compliance paths

1. Meet Passive Survivability requirements (part 1 of credit) using back-up power
2. Satisfy critical loads in building:
    - First identify critical loads
    - Provide back-up power for at least three critical loads from a list of options
    - Duration requirements vary by building type: 4 days for residential bldgs., lodging, healthcare
    - Duration requirement halved when back-up power provided by renewable energy system

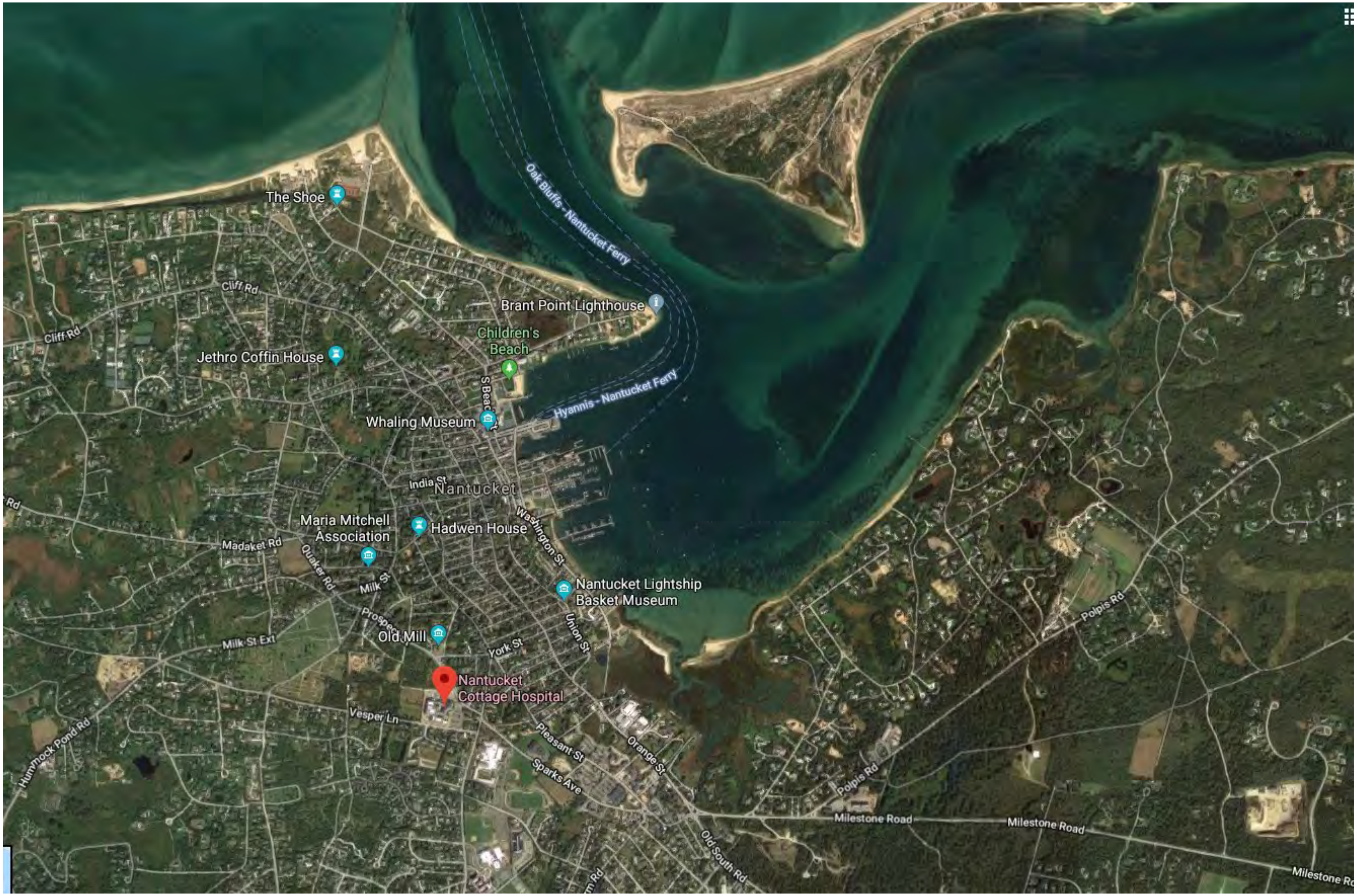
Photo: Alex Wilson

Nantucket Cottage Hospital

Passive Survivability Modeling Case Study



town
Rochester
Wareham
Sandwich
Brewster
Bourne
Dennis
Acushnet
Marion
Barnstable
Chatham
Harwich
Mashpee
New Bedford
Dartmouth
Falmouth
Buzzards Bay
Naushon
Island
Vineyard Sound
Oak Bluffs
Martha's
Vineyard
Edgartown
Chilmark
Nantucket Sound
Wauwinet
Nantucket
Cottage Hospital


The Shoe
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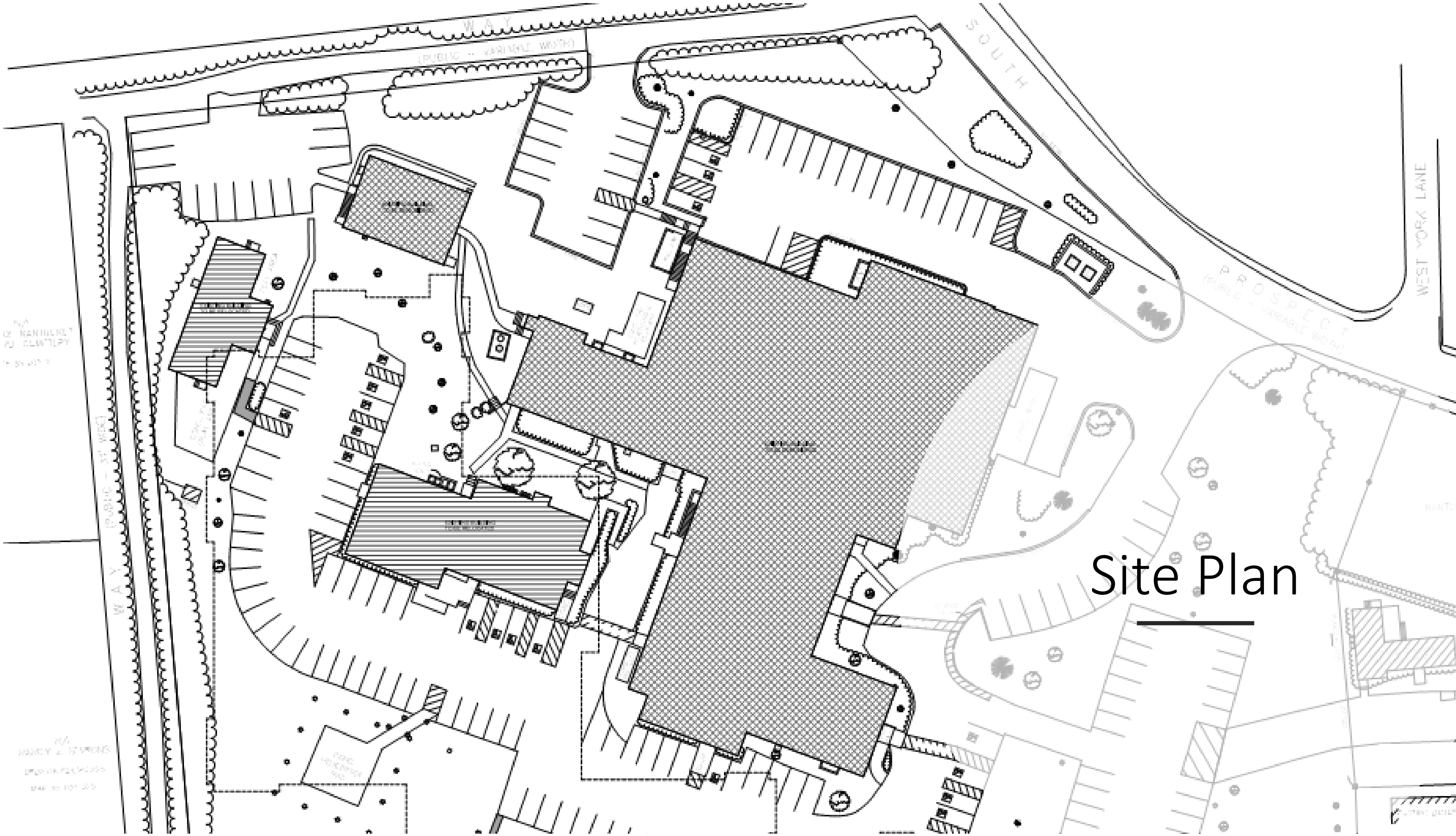
Cliff Rd
Brant Point Lighthouse
Children's Beach
Cliff Rd
Jethro Coffin House
Hyannis - Nantucket Ferry
Whaling Museum
India St
Nantucket
Maria Mitchell Association
Hadwen House
Madaket Rd
Quaker Rd
Washington St
Milk St
Nantucket Lightship Basket Museum
Prospect
Union St
Milk St Ext
Old Mill
York St
Polpis Rd
Nantucket Cottage Hospital
Vesper Ln
Pleasant St
Hummock Pond Rd
Orange St
Sparks Ave
Polpis Rd
Milestone Road
Milestone Road
Old South Rd


WAY
(PUBLIC – VARIABLE WIDTH)
SOUTH
PROSPECT
(PUBLIC – VARIABLE WIDTH)
WEST YORK LANE
WAY

Site Plan

IPpc100 Compliance Path

Passive Survivability and Functionality During Emergencies

Option 1 – Thermal Resistance

Option 2 - Back Up Power

Redundant Fuel Fired Generator System

Operable Windows

Option 3 - Potable Water

Two Municipal water connections

Fixtures - 10psi without booster pumps

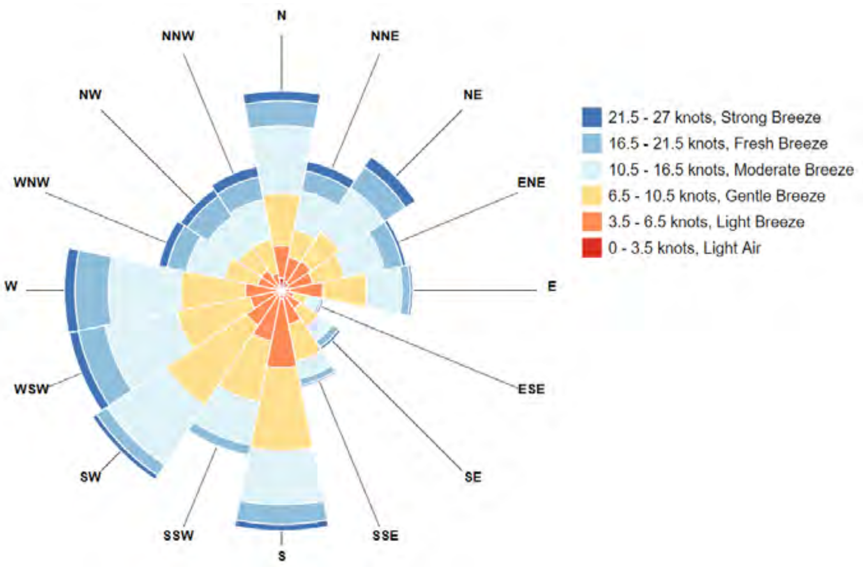


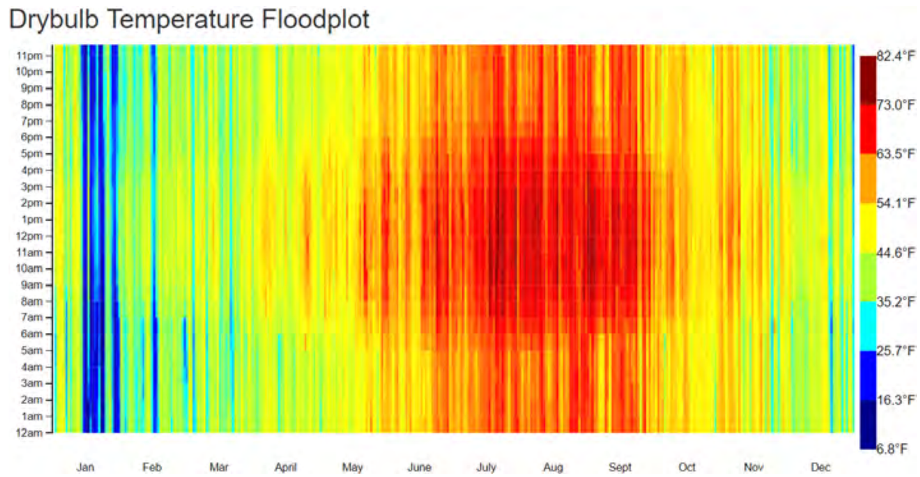
Passive Survivability Credit Criteria

Hot Summer Week	Not to exceed 216 °F·SET-Hour above 86 °F SET
Cold Winter Week	Not to exceed 216 °F·SET-Hour below 54 °F SET
Natural ventilation	Old credit language: 5 CFM/person ≈ 3-5 ACH
HVAC and Internal Loads Off	
Natural or Designed Shading May be Included	

Energy Modeling Assumptions/Challenges

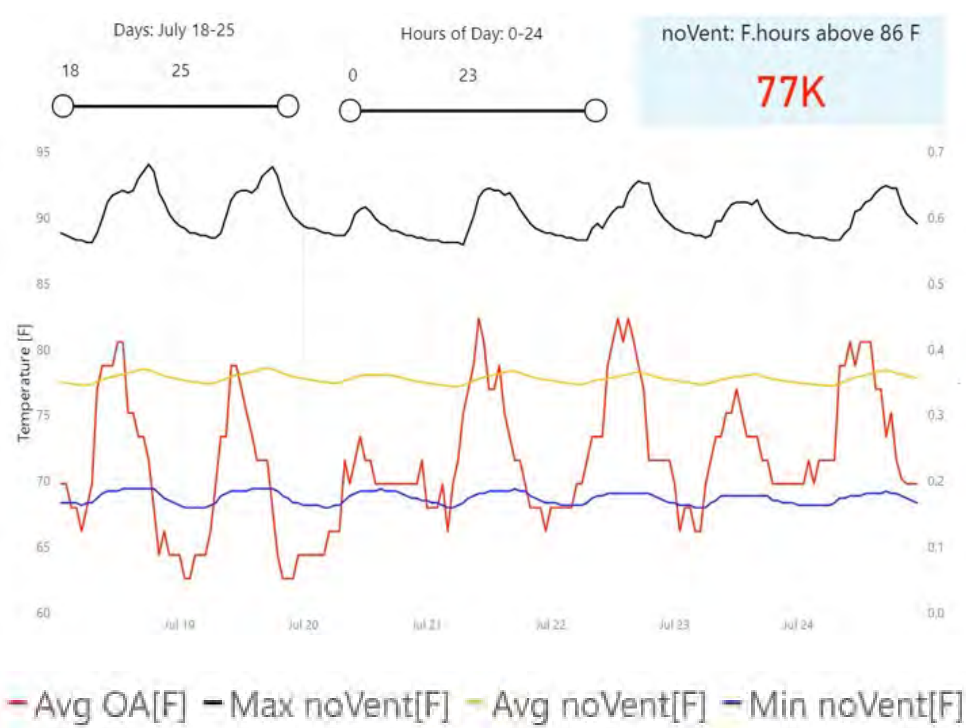
- Standard Effective Temperature (SET) vs. Operative Temperature (OPT)
- Design Thermal Properties:
  - R-30 Roof & R-13 + R-7.5 (c.i.) Walls
  - Glazing U-0.29 and SHGC 0.38
- Outdoor Air Temperature (OA)
  - Summer: OA < 86 °F & less than 9 °F warmer than Indoor Temp
  - Winter: OA > no limit & less than 18 °F colder than Indoor Temp
- Natural Ventilation Criteria
  - No Ventilation
  - 4-inch effective window heights
  - 1-inch effective window heights
- No Shading Mechanism Modeled





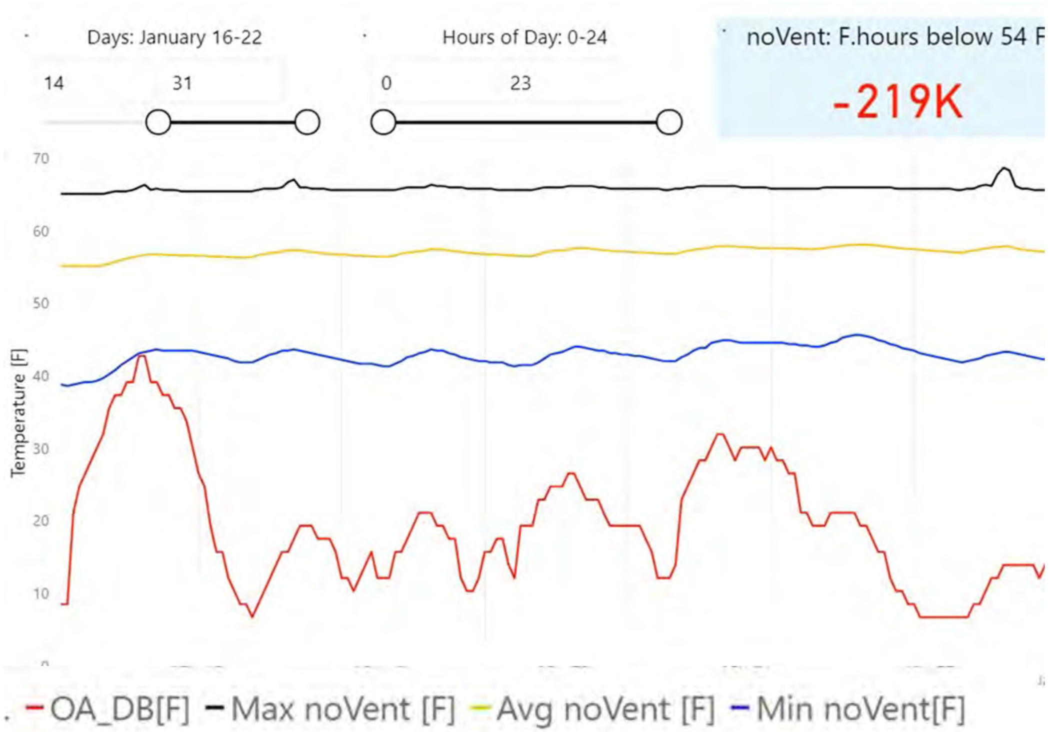
Nantucket Climate Data

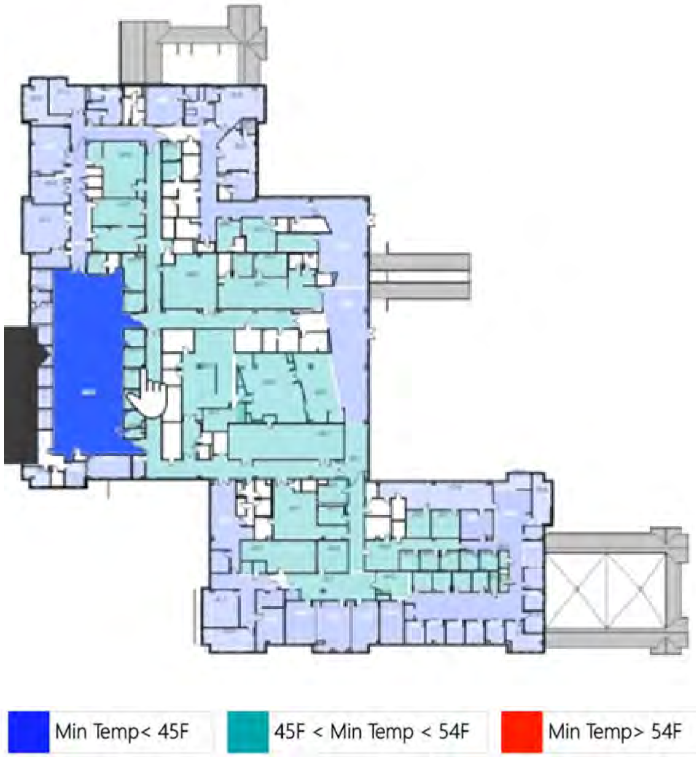
Summer – Peak Cooling



[BI Dashboard]

Winter – Peak Heating





BI Dashboard

Summary

Summer Hot Week Degree-Hours Meet Credit Criteria

Winter Cold Week Degree-Hours Don’t Meet Credit Criteria

Comfort Temperatures vs. Minimum Ventilation is complicated!

Ventilation requirements need clarification

Modeling Software Capabilities Don’t Align with Reporting Needs

Three take-away points:

1. More energy-efficient buildings are more resilient
2. Keeping people safe can be a motivation for creating highly energy-efficient buildings
3. While this is an adaptation strategy, it also reduces energy consumption and CO_2 emissions—so it is a climate change mitigation strategy

Alex's renovated, net-zero-energy house in Dummerston, Vermont – photo: Alex Wilson

Three take-away points:

Exercise:

- Form groups of 6 to 8
- Introduce yourselves
- Pick one project that someone has actually done
- Determine what you would need to do to achieve IPpc100 for the chosen project

Three take-away points:

Report Out:

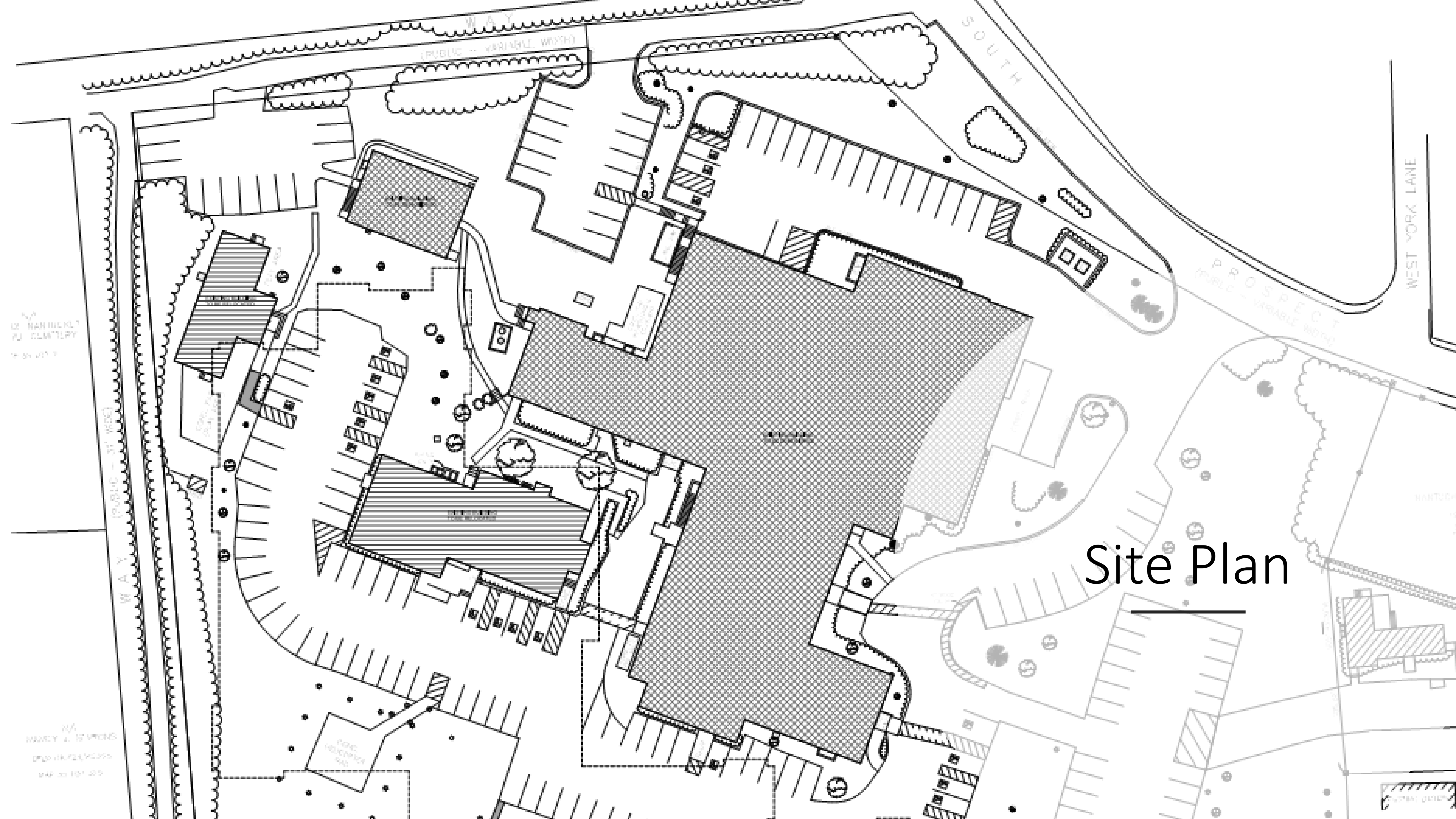
Answer the question:

How has this exercise changed how you would go about projects?

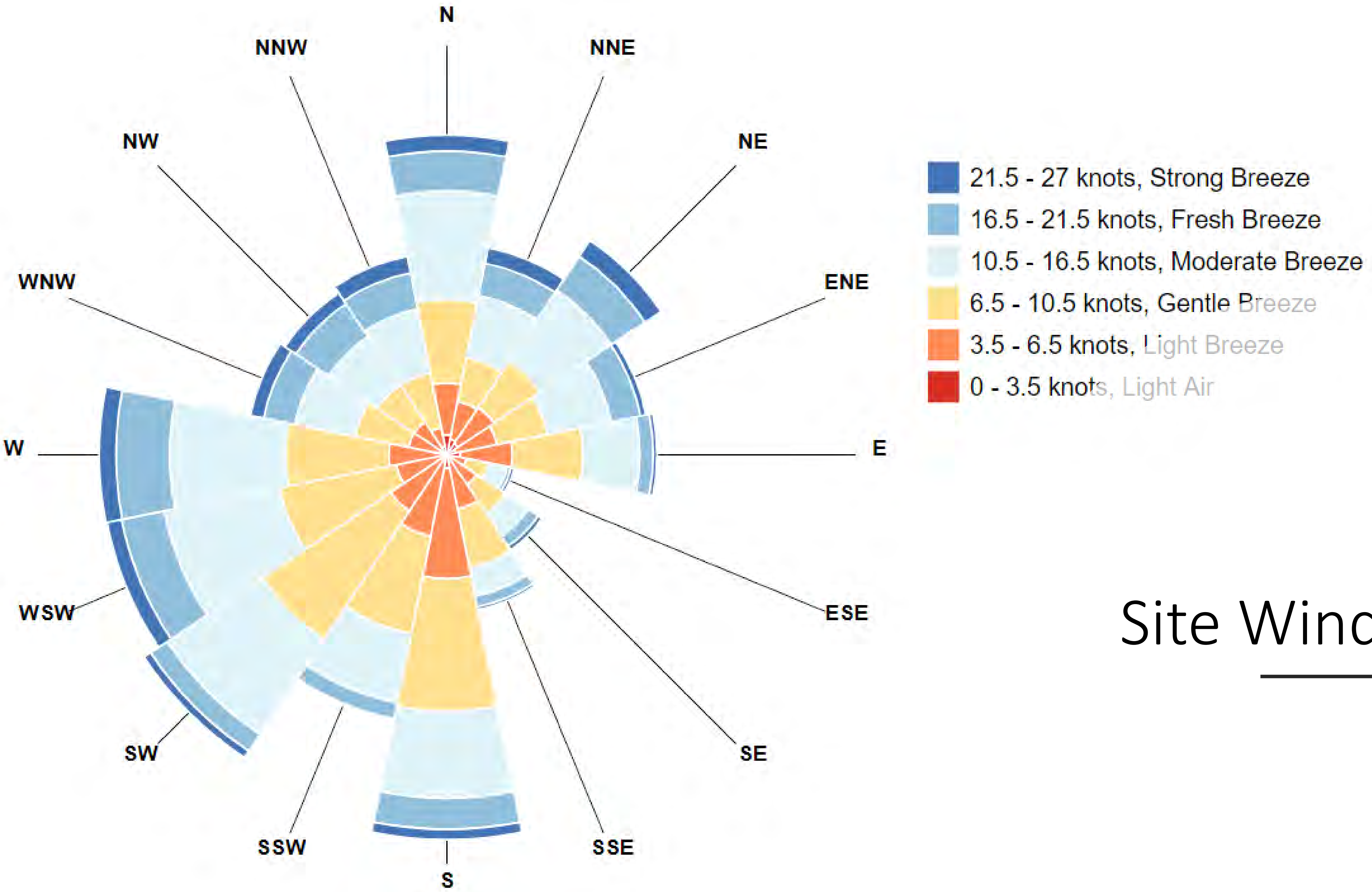
Passive Survivability Modeling Case Study

Nantucket Hospital

Site Plan

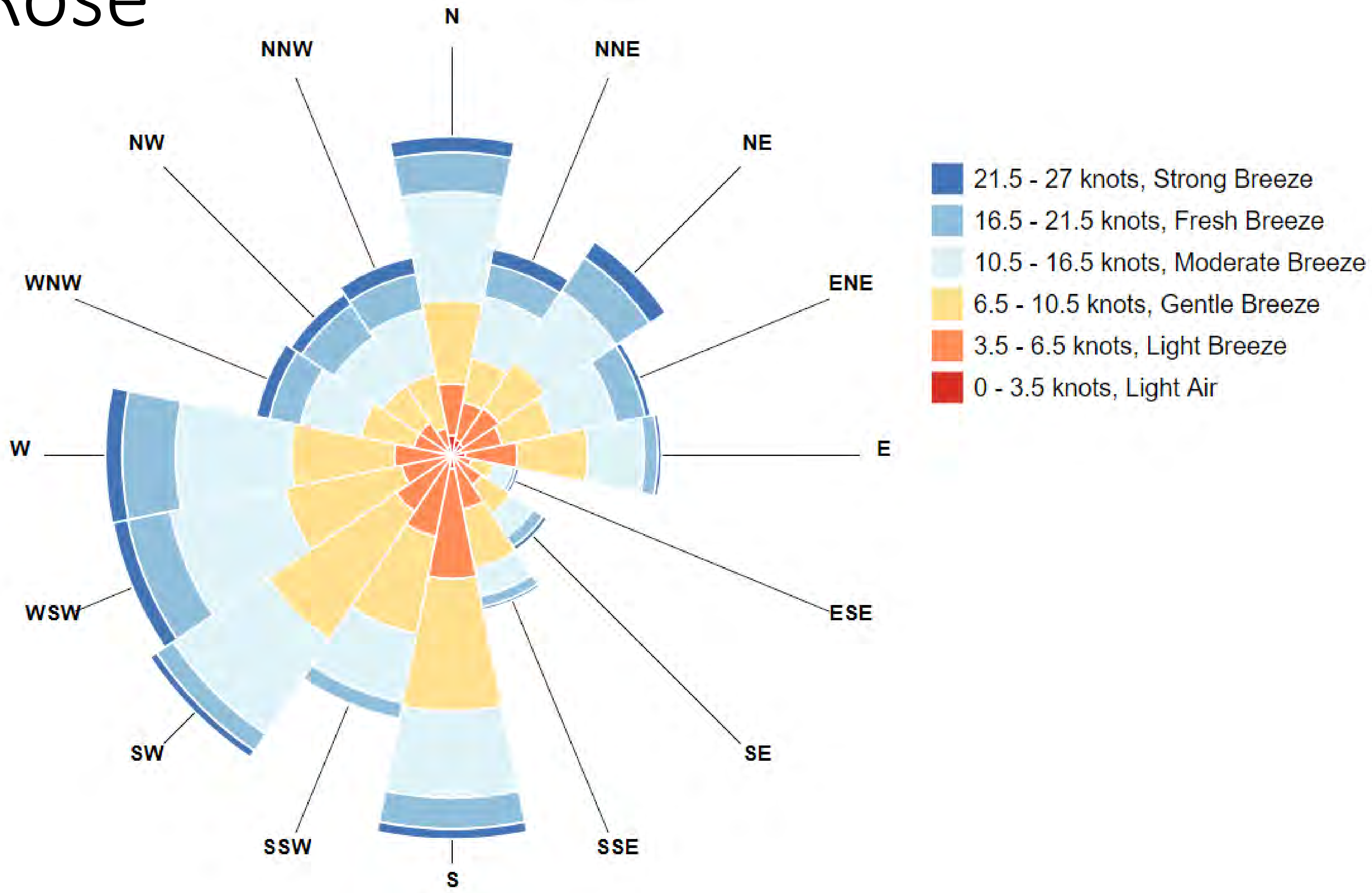


Floor Plans



Site Wind Rose

Site Wind Rose



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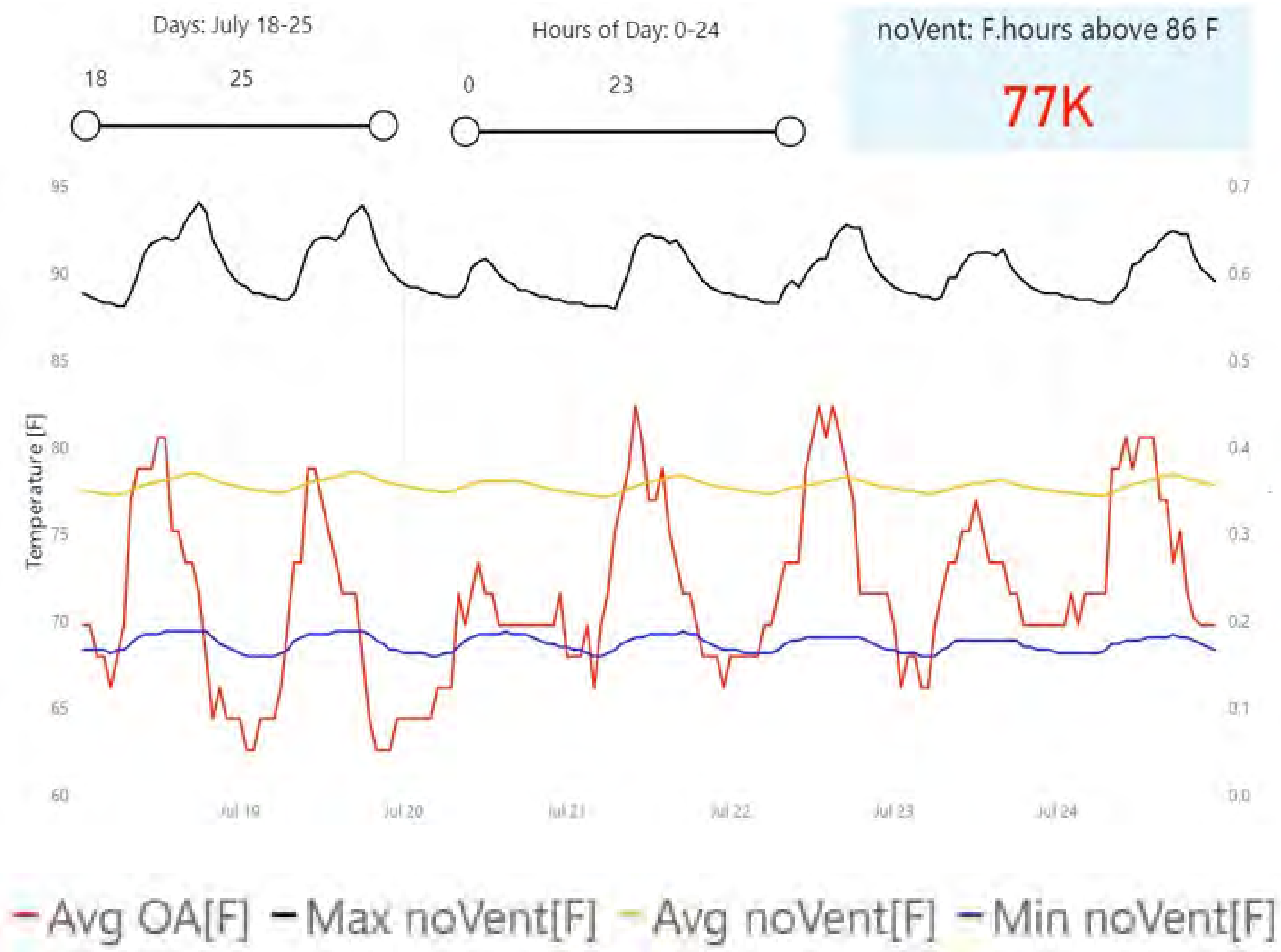
Natural Ventilation Criteria

No Ventilation
4-inch effective window heights
1-inch effective window heights

No Shading Mechanism Modeled

Summer Week


Days: July 18-25
18
25
Hours of Day: 0-24
0
23
noVent: F.hours above 86 F
77K
Temperature [F]
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Jul 19
Jul 20
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Jul 22
Jul 23
Jul 24
Avg OA[F]
Max noVent[F]
Avg noVent[F]
Min noVent[F]


Max Temp< 75F
75F < Max Temp < 86F
Max Temp> 86F

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- Ventilation requirements need refinement
- Modeling Software Capabilities Don’t Align with Reporting Needs