R & D Hootenanny

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8 Oct 2025

Outline

0. Preamble
1. Topics that have come up
2. Panelist highlight (1 each)
3. Audience participation

- Energy performance metrics & modeling protocol
- Non-energy guardrails
- Ventilation system design
- Design tools
- Quality assurance
- Policy support
- Beyond the building scale
- Beyond the US context

0. Preamble

Still trying to convince people to insulate their houses 👉

The case for that, and the vision, expanded…

Pursuing our vision via standards and certifications raised some technical issues…

…as expected

~2009. Purposes, per bylaws
Conduct, lead, and coordinate research in passive-house-related building sciences in the United States, particularly regarding energy, heat transfer, ventilation, and moisture;
Educate…
Train…
Certify…
Test…
Design, build…

~2017. Vision/Mission
- Make high-performance passive building commonplace.
- Develop and promote North American specific standards, practices and certifications for buildings, professionals and products to create structures that are durable, resilient, comfortable, healthy and super energy efficient.

~2019. Vision
Every building supports the health of people and the planet.

~Current. Mission/Vision
The Phius mission is to support comfortable living for all and the well-being of the planet.

Katrin Klingenberg: “Phius was founded to create a carbon-neutral, healthy, safe, and just future for everyone by mitigating the climate crisis.”

Performance Concepts

No heating bill 👊 No big furnace/boiler 👊

(Modeled) Performance Metrics

Annual heating load, peak heating load, annual source energy…

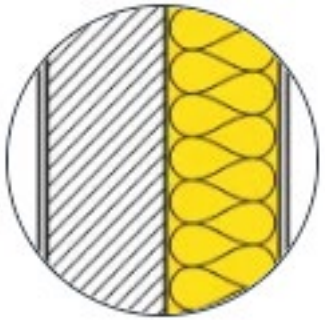
Performance Standard

AHD ≤ X, SE ≤ Y…

Modeling protocol

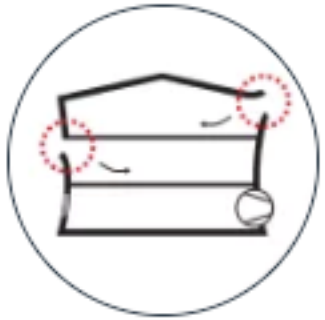
For each and every thing

Thermal Control



Including heat & cold storage, phase change, ground coupling

Air Control

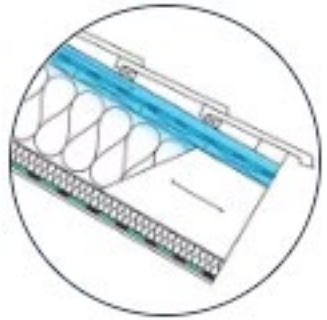


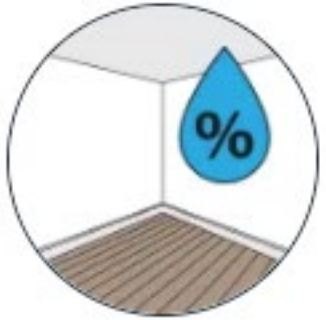
Including natural ventilation cooling, evaporative cooling, cooling fans, combustion air control

Radiation Control

Including roofs, site shading, building orientation and aspect

Moisture Control





Including moisture storage, dessicant cycles

phius

1. R&D review

Some of which we have better answers for than others…

Topic areas

Energy performance metrics & modeling protocol

Non-energy guardrails

Ventilation system design

Design tools

Quality assurance

Policy support

Beyond the building scale

Beyond the US context

Performance metrics & modeling protocol

Performance metrics

- Annual htg, clg energy
  - Annual “coil loads”
- Peak htg, clg, dehum power
- Annual source energy
  - Net Zero
- Operational GHG emissions
- Resilience thermal, electrical
- Life cycle
  - Cost, embodied carbon

Modeling protocol issues

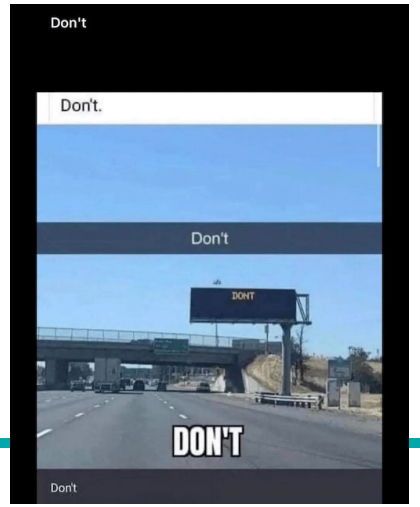
- 3d thermal bridges
- Ground contact
- Solar heat - site shading & reflections
- Hygric buffering
- Daylighting
- Site-source factors, cogeneration, PV, Solar HW
- Complex & integrated mechanicals
- Thermal & electrical storage
- Occupant behavior – diversity factors, DHW, dryers, DCV, intermittent exhaust, occupancy sensors
- Weather data – past vs future, typical vs extremes

Non-energy guardrails

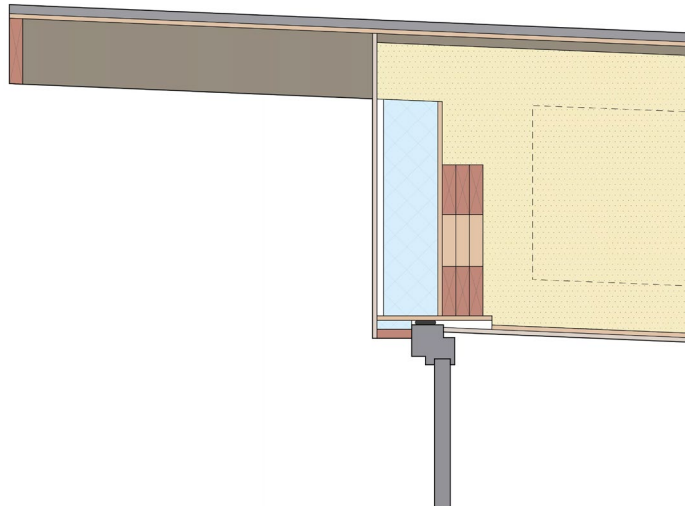
- Air sealing, durability thereof
- Moisture risk / hygrothermal
  - Prescriptive rules
  - WUFI calc protocol
- Condensation resistance (esp. window prog.)
- **Indoor air quality**
- Site hazard fortification
  - Land use triage

Ventilation system design

- Coupled vs. decoupled air systems
- Centralized vs. decentralized
- Intermittent vs. continuous
- Direct exhaust & makeup air - bath / range / dryers
- Fireplaces



Design tools



- Catalogs - details, hygro
- Software tools. Side calculators. Multizone buildings, Nonresidential use patterns, complex mechanicals, complex foundations.
- THERM vs. Flixo
- Parametrics & Optimization
  - Parallel coordinates, Genetic algorithms

Quality Assurance

Design verification

- EPA / DOE vs. ASHRAE Commissioning
- Non-US projects
- ASHRAE 140 software validation
- Design review form / QA checklist workbook

Field Verification

- Electrical power measurement
- Air-tightness testing
- Ventilation - coupled duct systems and CAR dampers
- Residential vs. nonresidential
- Implementation review form / QA checklist workbook

Post-occupancy

- System or homeowner manual
- Monitoring and Ongoing Commissioning

Policy Support

- Parametric simulation studies - various building types in various climates. Basements.
- Modeling crossover (% better than X, what's that in HERS…)
- ANSI approved standard - ASHRAE 227 still in progress 😳
- **Monitoring**

Beyond the Building Scale

- Grid citizenship, grid-interactive efficient bldgs (GEB)
- Electrical Microgrids
- Thermal Energy Networks

Beyond the North American context

- Cultural – what is the building delivery process, who is trusted
- Capability differences esp. for verification and test

2. Panelists highlight an issue / cause

- One each

Haley: REVIVE 2024 Resilience Criteria

Current Criteria

6.4.2 Summer Thermal Resilience Criteria

During the simulated outage, each *thermal block* shall have:

a. Heat Index: Zero hours in Danger, Extreme Danger, and
b. Zero deadly days per Mora et al.

Deadly day criterion:
During the summer outage,

Tday <= Tdead, where

Tdead [F] = 121.91 - 87.444*RHday + 46.597*RHday^2
Tdead [C] = 49.593 - 48.580*RHday + 25.887*RHday^2
Tday is the mean daily temperature in the *thermal block*.
RHday is the mean relative humidity in the *thermal block*, as a fraction 0 ≤ RHday ≤ 1.

Phius ZERO REVIVE 2024

6.4.1.1 Tier A Summer Resilience Decarbonized:

- Onsite renewables must be capable of covering all summer-critical electrical and process loads

Phius CORE REVIVE 2024

6.4.1.2 Tier B Summer Resilience

- Summer-critical electrical and process loads must be covered by any type of on-site backup power generation

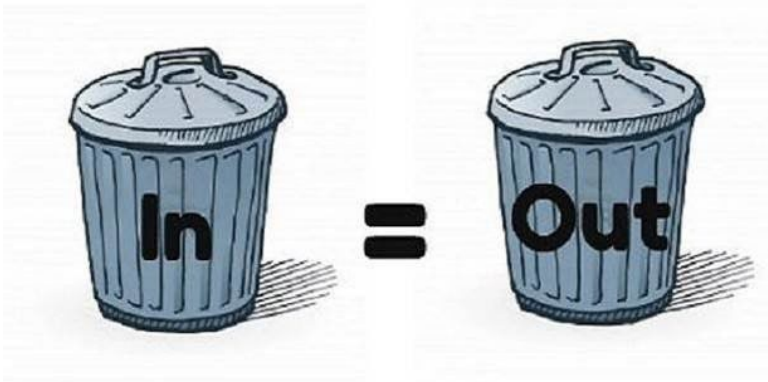
Haley: REVIVE 2024 Resilience Criteria

- Issue: Batteries!
- Feasibility studies resulted in cooling battery size estimates beyond what is reasonable to ask of project teams / homeowners / anyone attempting to retrofit cost-effectively
- Gas generators *are* technically permitted (CORE tier), but that defeats what we are trying to accomplish – electrification & decarbonization
- Need to make it more achievable for REVIVE-ers to implement PV + battery
- ~~Mora~~

AI: Measurement and Verification

Measurement and Verification

- Models are only as good as their assumptions
- Assumptions can be made from standards
  - BAHSP
  - RESNET 301
  - ASHRAE 90.1
- Measurement is best to determine
  - Informs more than just modeling protocol



AI: Measurement and Verification

Tiers:

1. Whole Building Utility Data
    1. Easy, affordable
    2. Sometimes you get the right result for wrong reason
2. End use energy
    1. Better, more costly
    2. Ignores equipment efficiency
3. Full monitoring
    1. Best, very pricey
    2. Some uncertainty in terms of mass balance

$$CVRMSE = 100 * \frac{1}{\bar{y}} [\sum (y_i - \hat{y}_i)^2 / (n-p)]^{1/2}$$

$$NMBE = \frac{\sum^n (y_i - \hat{y}_i)}{(n-p) * \bar{y}} * 100$$

n= number of data periods (at least 12 months ⟶ n=12)
p = number of parameters in baseline model (p=1)
y_i = meter energy data for period i
$\bar{y}$ = mean of meter energy data
$\hat{y}_i$ = simulation-predicted energy data for period i

Statistic	Monthly	Hourly
CV(RMSE)	15%	30%
NMBE	5%	10%

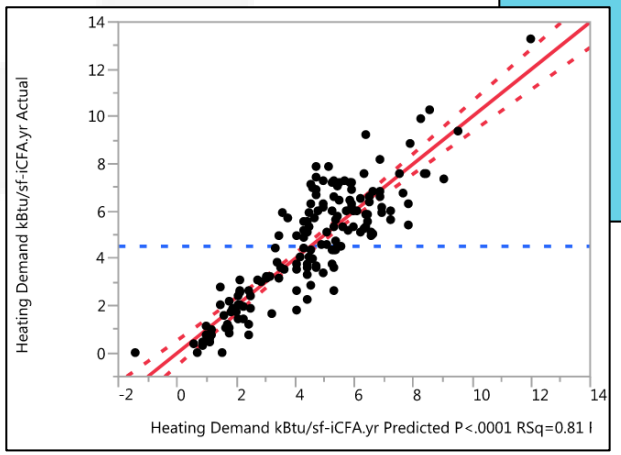
CVRMSE – Shape of data
NMBE – Total of data

Use these over percentage difference
*ASHRAE 14-2014

James – Let's Zoom In?

Current Phius Standard Development

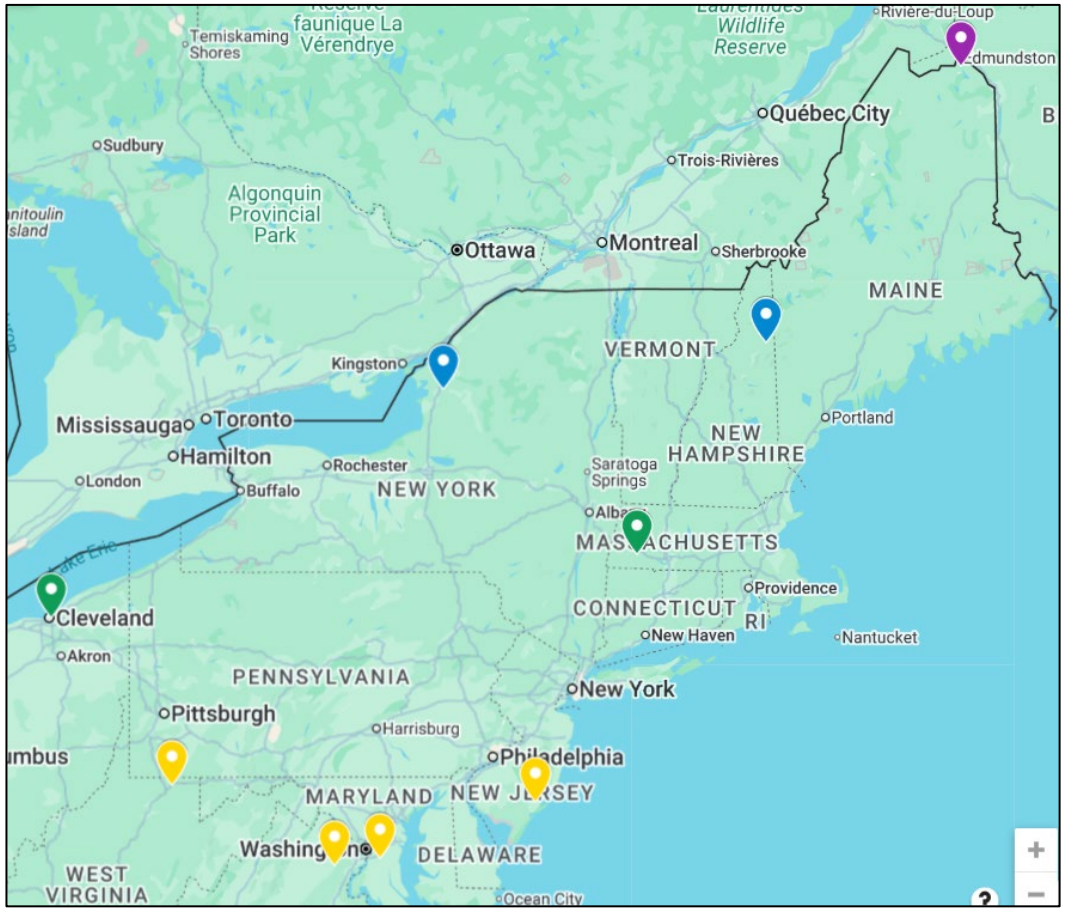
- MACRO to micro
- Extreme / Stress Cases
- Regression Formulas & Best-Fit Curves



James – Let's Zoom In?

Future: More Localized Studies

- Macro to Micro
  - State instead of Country?
- Extreme / Stress Cases
  - Increase Density
- Regression Formulas & Best-Fit Curves
  - Localized



Graham – Air Sanitation

"Over a century ago, water treatment and sewer systems revolutionized public health, but modern buildings still need similar systems for monitoring and improving indoor air quality." – ARPA-H

Waterborne: Typhoid, Cholera
Airborne: Flu, Covid-19, Measles, Tuberculosis

Tools (other than PPE and over-ventilation)

- Filtration
- Germicidal UV (beware photocatalytic oxid.)
- Real time biosensors (coming)

Resources
ASHRAE 241 – Control of Infectious Aerosols

- Infection risk management mode
- Equivalent clean airflow rate per occupant

ASHRAE Position on Filtration & Air Cleaning

- "beware of side effects, e.g. ozone"

Covid-19: a mass disabling phenomenon

Fatality rate ~ 0.001% young to 0.5% old
Disability rate ~ 5%
Vaccine doesn't prevent transmission :/
~25% chance of long covid per infection
Post-Covid

- Extreme tiredness after activity
- Brain fog
- Heart and circulation – POTS, strokes, clots
- Loss of taste/smell
- Chronic fatigue
- Diabetes
- Exacerbates migraine, lung disease, autoimmune and kidney disease
- Immune system damage

Graham – Air Sanitation

ARPA-H BREATHE
https://arpa-h.gov/explore-funding/programs/breathe

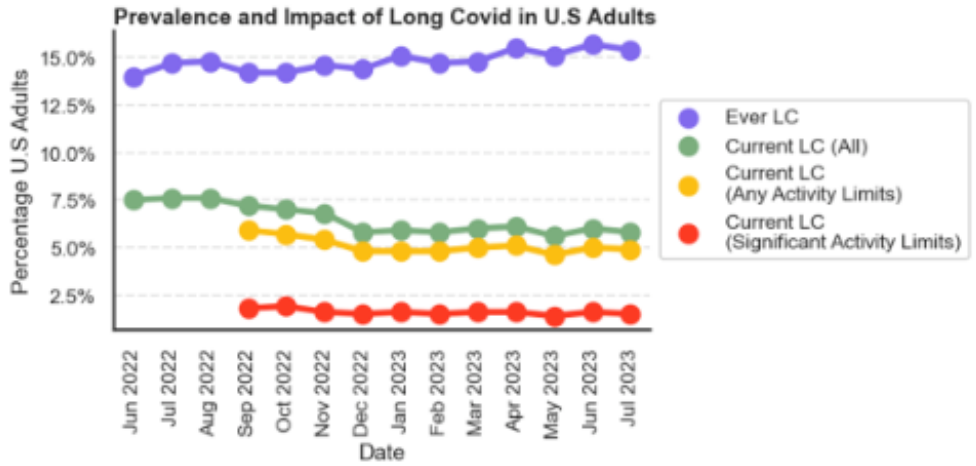
Covid Fatality rate
https://pmc.ncbi.nlm.nih.gov/articles/PMC9613797https://

Covid Disability rate
www.medpagetoday.com/opinion/second-opinions/105599/

Vaccine doesn't prevent transmission
https://www.science.org/content/blog-post/coronavirus-vaccination-room-improvement

Every time you get covid there's a ~25% chance of some post-covid / long-covid problem.
https://www.cidrap.umn.edu/covid-19/studies-across-14-nations-show-25-30-rate-long-covid

Post covid syndrome - "the sting in the tail", "subtle but the damage is real".
https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/coronavirus-long-term-effects/art-20490351
https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/covid-long-haulers-long-term-effects-of-covid19
https://www.infectioncontroltoday.com/view/covid-19-study-suggests-long-term-damage-immune-system
https://www.chicagotribune.com/2025/09/30/long-covid-children-lurie-study/?s=04
https://www.mdpi.com/2673-8112/5/9/156
https://www.neurology.org/doi/10.1212/WNL.0000000000214226

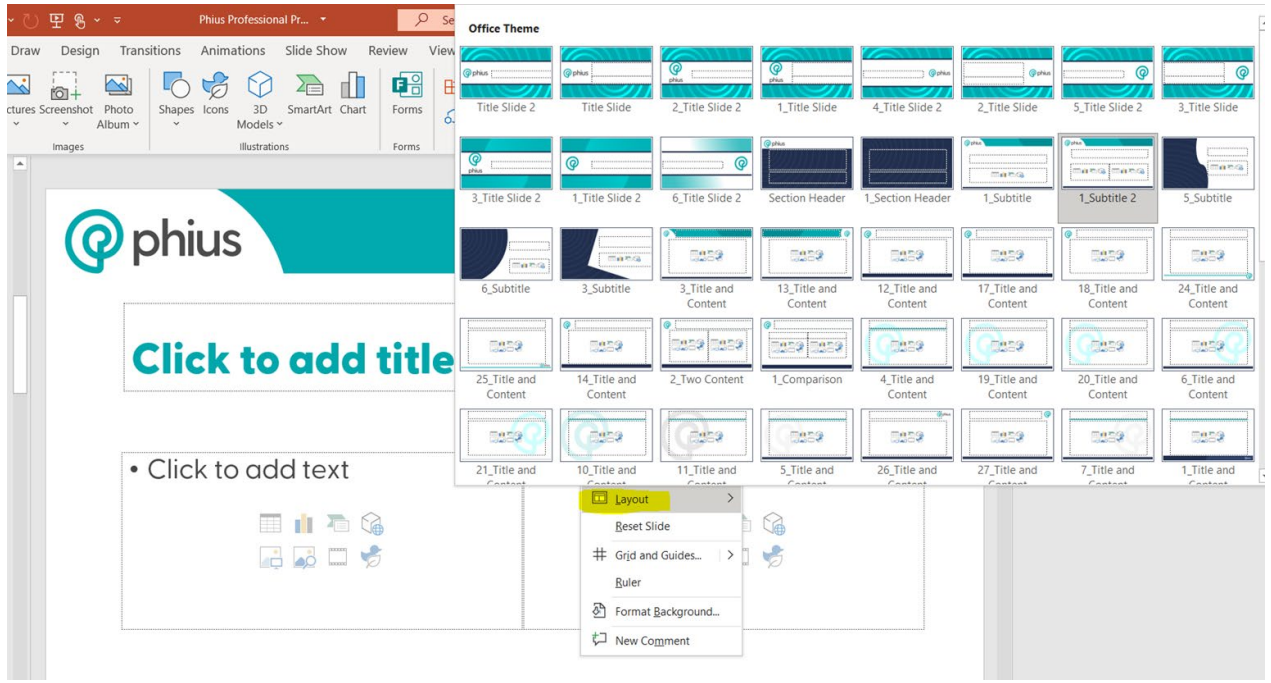


Original graphic from Joshua Ashkinaze, based on CDC data.

3. Audience participation

Open discussion

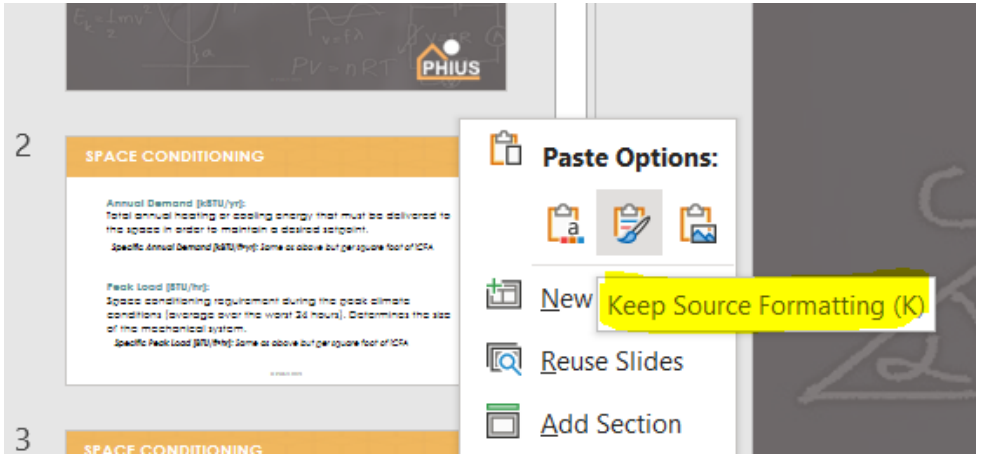
INSTRUCTIONS TO USE TEMPLATE



- To use the layouts in the deck, click ‘Insert > New Slide’ and select the layout.
- You can change the layout on any slide by right clicking on the slide and selecting ‘Layout’ – you’ll see the full box of layout options appear

INSTRUCTIONS TO APPLY TO EXISTING PPT

- To apply this Master template to another existing PPT deck, copy a single slide from below, and right click ‘Paste – Keep Source Formatting’.
- Then, you can change the layout on any slide by right clicking and selecting ‘Layout’ (as shown in the previous slide)



COLOR PALETTE

Color system

Brand colors help give our brand its personality. These are the colors we use in our communications. Core brand colors should form the primary palette for all projects. Secondary colors may be used as an accent in very small quantities.

- The colors should automatically come in with the deck. If they do not, here is the color palette.

Core colors

TEAL		NAVY BLUE		TAN	
CMYK	77, 10, 34, 0	CMYK	99, 84, 44, 46	CMYK	6, 4, 11, 0
RGB	0, 70, 175	RGB	14, 39, 70	RGB	237, 236, 224
HEX	#00AAAF	HEX	#0E2746	HEX	#EDECE0

Secondary colors

PURPLE		ELECTRIC BLUE	
CMYK	68, 86, 7, 1	CMYK	68, 52, 0, 0
RGB	110, 70, 146	RGB	85, 128, 253
HEX	#6E4692	HEX	#5580FD

YELLOW		CITRON	
CMYK	0, 18, 89, 0	CMYK	17, 0, 77, 0
RGB	255, 207, 52	RGB	223, 253, 97
HEX	#FFCF34	HEX	#DFFD61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