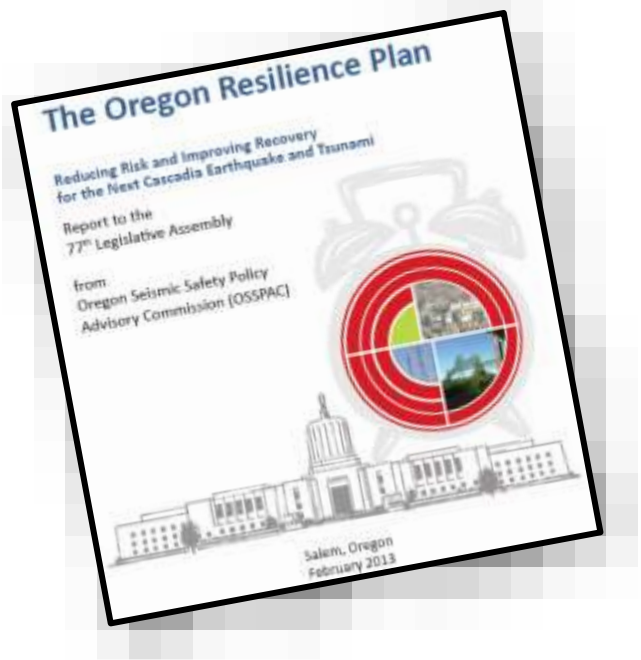
Sustainable and Resilient School Design

Richard Steinbrugge, PE
Executive Administrator for Facilities
Beaverton School District

Kent Yu, PhD, PE, SE
SEFT Consulting Group

Jay Raskin, FAIA
Jay Raskin Architect

The Oregon Resilience Plan

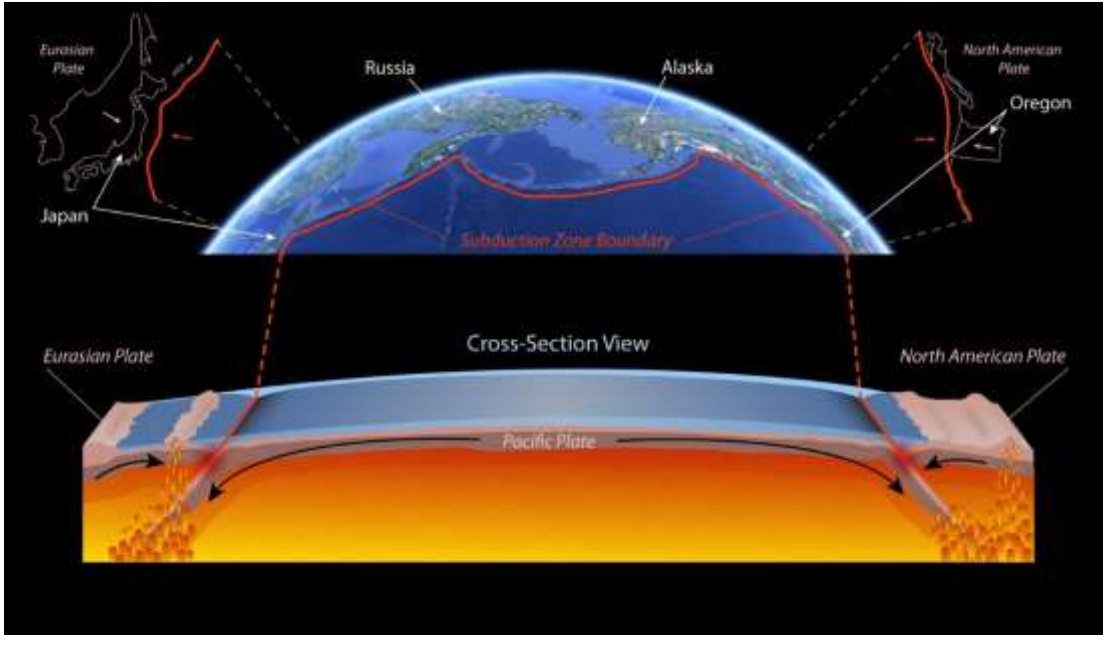


50-year Comprehensive Plan

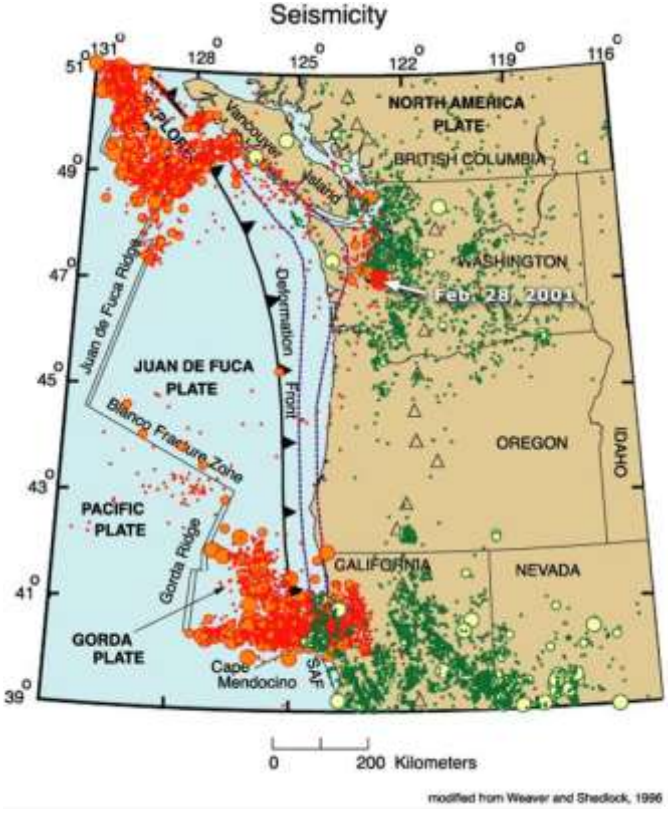
- ❑ **Cascadia Earthquake Scenario**
- ❑ **Business/Workforce Continuity**
- ❑ **Coastal Communities**
- ❑ **Critical & Essential Buildings**
- ❑ **Transportation**
- ❑ **Energy**
- ❑ **Information and Communication**
- ❑ **Water & Wastewater**

- ❑ Save Lives, protect our economy, and preserve our communities;
- ❑ 169 Expert Volunteers;
- ❑ $ Millions in donation of professional services over a year

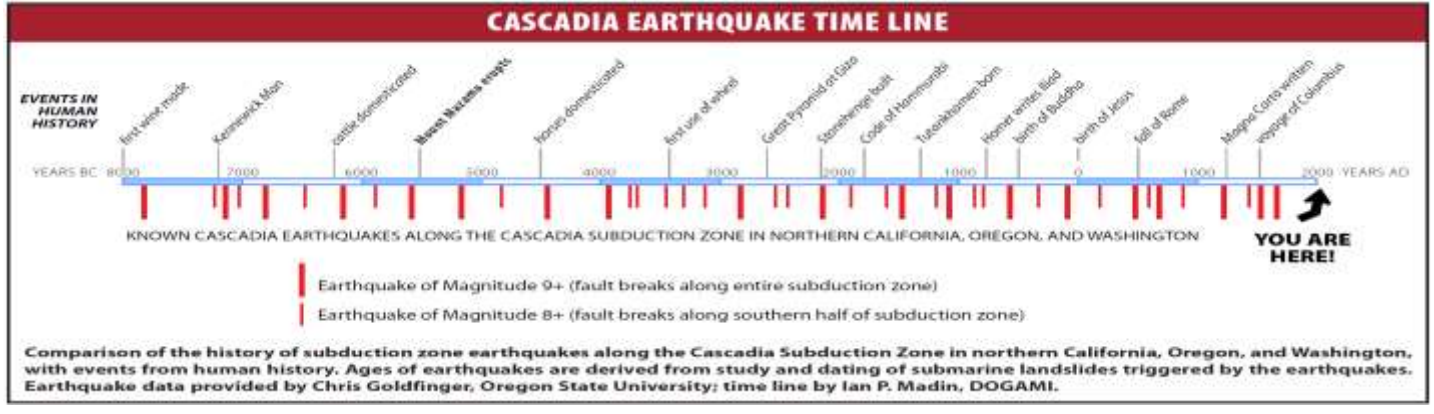
Oregon Seismic Hazard

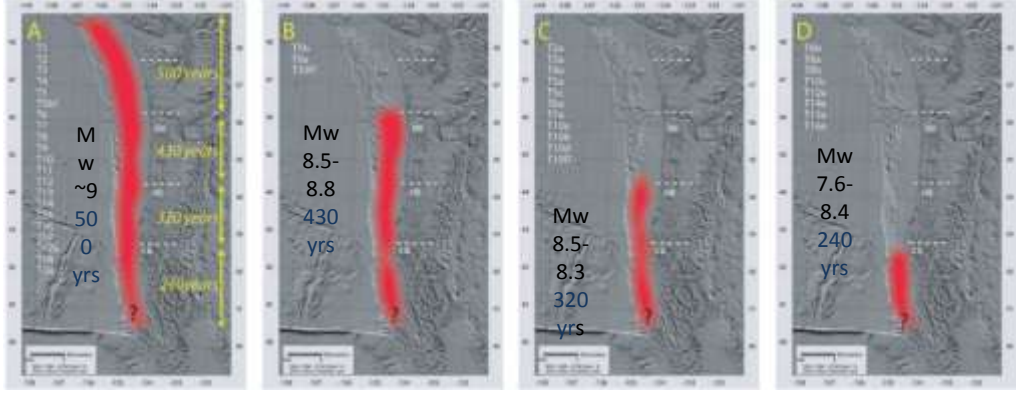


(OSSPAC 2013)



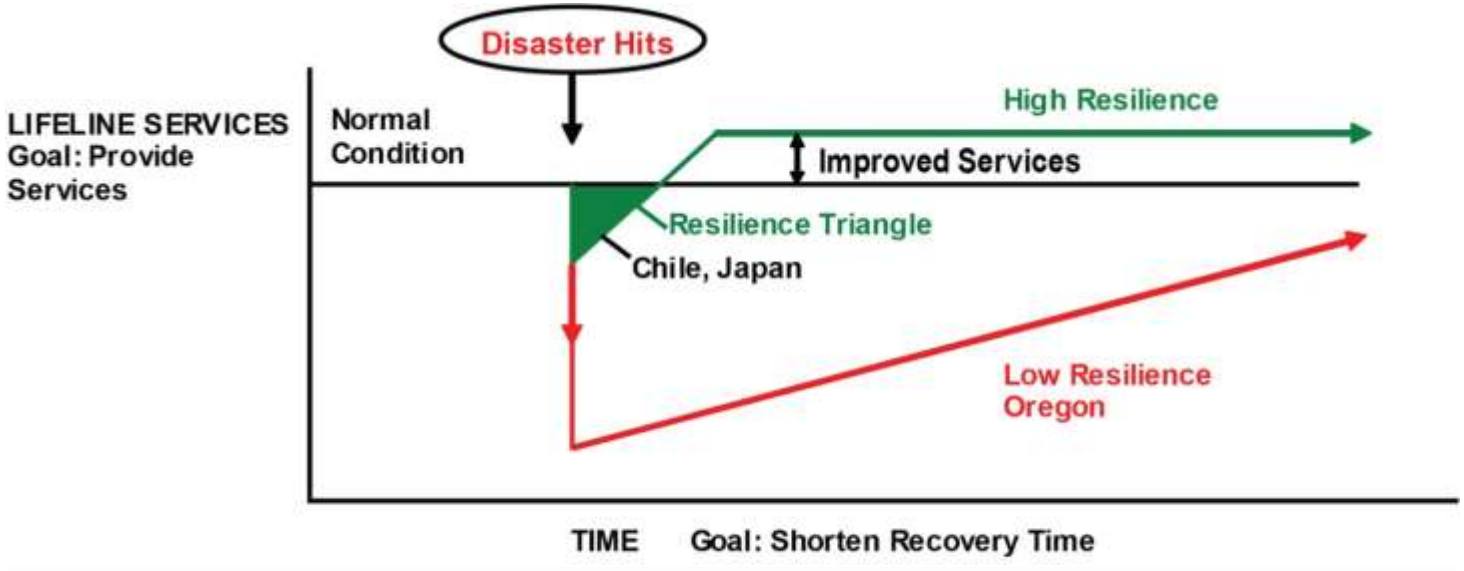
Oregon Seismic Hazard





(Modified from Goldfinger et al. (in press) by adding magnitude estimates and some labels)

Definition of Resilience

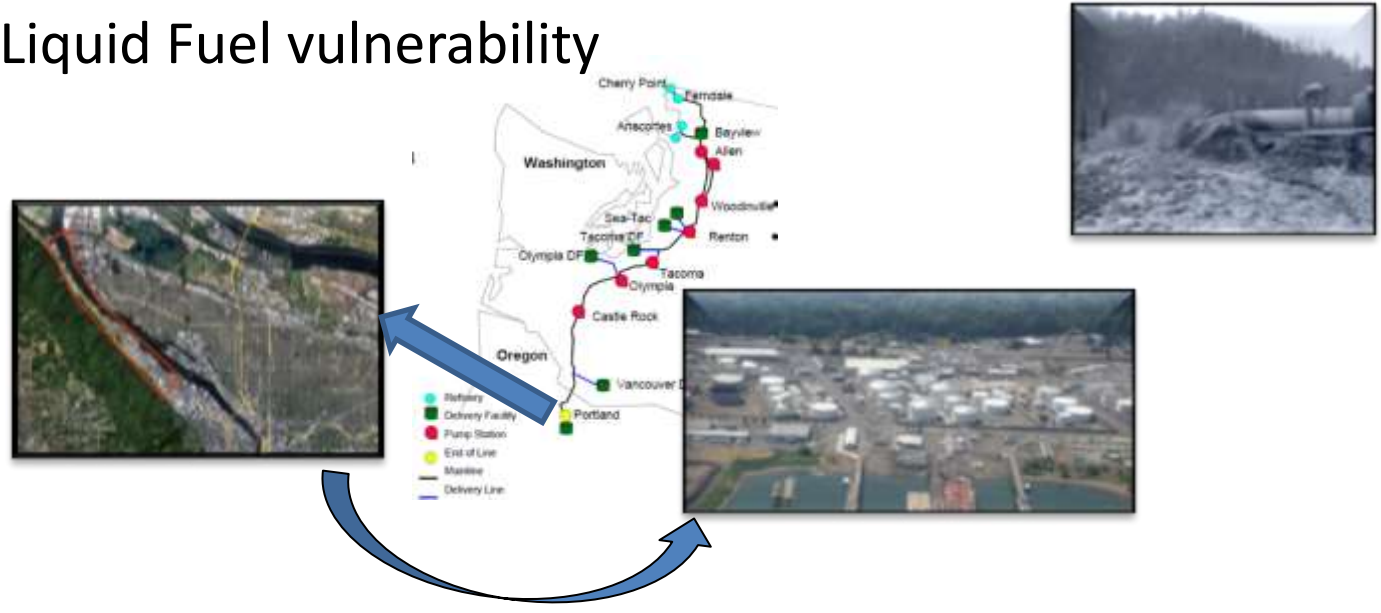


(Yumei Wang)

- The ability to *prepare for* and *adapt to* changing conditions and *withstand* and *recover rapidly* from disruptions (from PPD-21)

ORP Key Findings

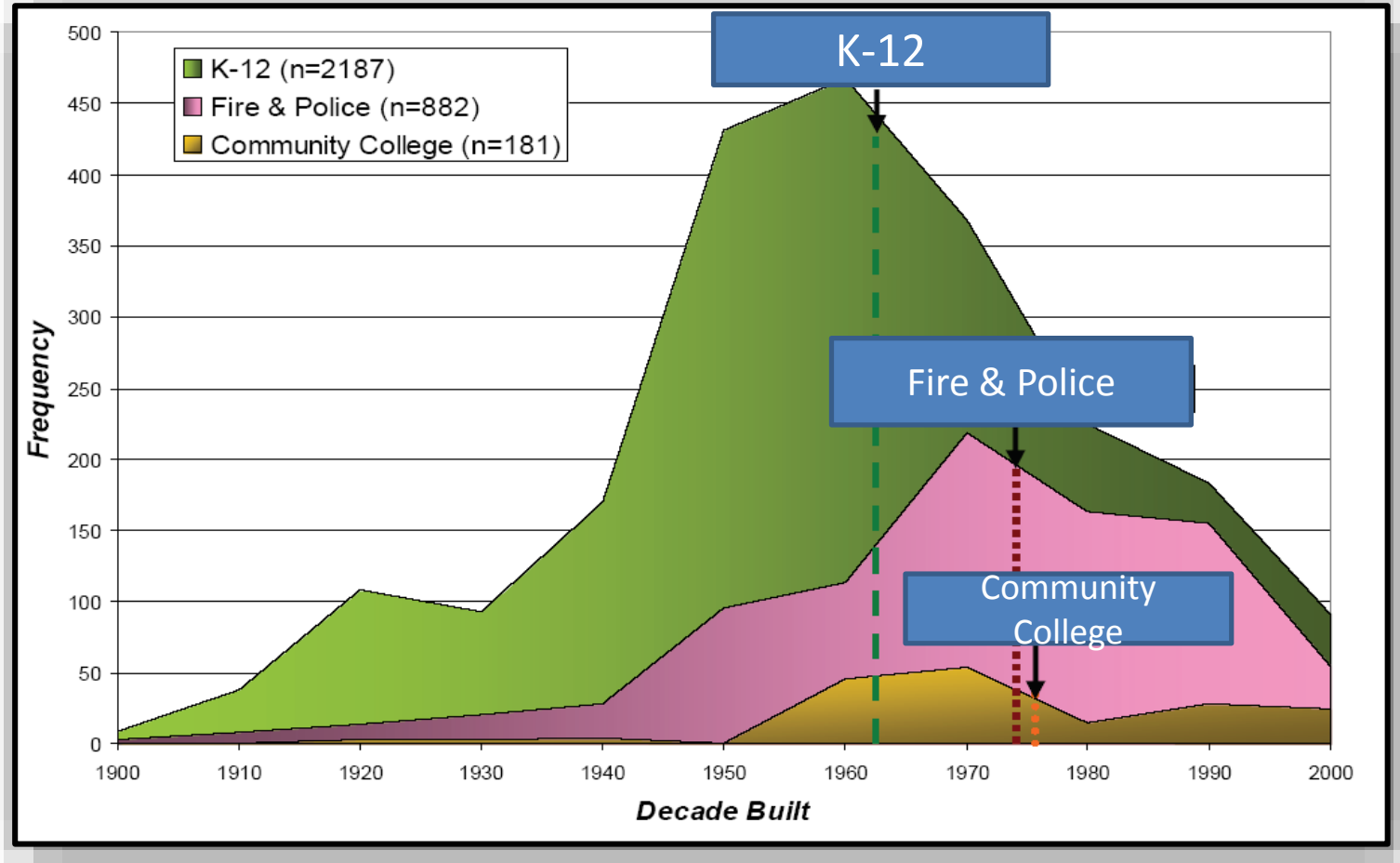
- Oregon is far from resilient to the impact of a great Cascadia earthquake today
  - Casualties (a few thousand to more than 10,000)
  - Economic Loss (at least 20% state GDP)
  - More than one million truck loads of debris
- Liquid Fuel vulnerability



ORP: Current Recovery Challenges

Critical Services	Zone	Estimated Average Recovery Time
Electricity	Valley	1 to 3 months
Drinking Water	Valley	6 months to 1 year
Sewer	Valley	1 to 3 years +
Top-priority Highways	Valley	6 to 12 months

Oregon Education & Emergency Facilities



Building Performance Gaps

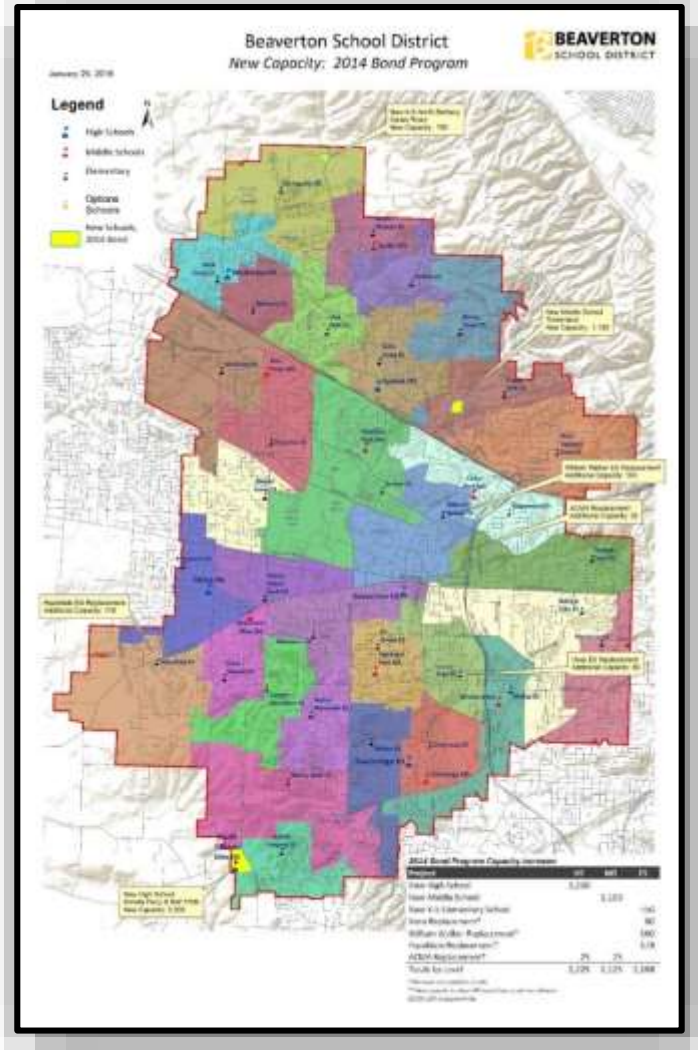
Critical Building Category	Zone	Estimated Average Recovery Time	Resilience Target
Healthcare Facilities	Valley	18 months	Immediate
Police and Fire	Valley	2 to 4 months	Immediate
Emergency Shelter	Valley	18 months	72 hours
Schools	Valley	18 months	30 days (60 days*)
Housing	Valley	3 days**	72 hours

* 30-day timeframe is preferred but a 60-day is also acceptable.

** Underestimates recovery for older construction

Beaverton School District

- 3rd Largest in Oregon; 40,000 students
- $680 Million Bond Program
  - Passed in May 2014; 8-year program
  - Modernization; New Capacity; Technology
- New Capacity Construction
  - High School
  - Middle School
  - K-5 Elementary School
- Replace four outdated Schools
  - Hazeldale, Vose and William Walker K-5's Arts & Communication Magnet Academy



Beaverton School District Bond Program

$680 Million Bond Program

- Passed in May 2014
- Construct **seven school buildings**

New Capacity Construction

- High School
- Middle School
- Elementary School (K-5)

Replace Four Outdated Schools

- Three K-5 school buildings
- One magnet school (6-12 grades)

Additional Investments

- $100M in capital repairs
- Classroom technology

Schools Serve as Shelters

Sumatra (2004)

Japan (2011)

Nepal (2015)

Super Storm Sandy (2012)

Stakeholder Workshop

- Local Emergency Response
  - American Red Cross
  - Washington County Emergency Management
  - TVFR, City of Beaverton
- Lifeline Service Providers
  - Electricity (PGE) and Gas (NW Natural)
  - Water (City of Beaverton, TVWD) & Wastewater (Clean Water Services)
- Beaverton School District
  - District Administration and Project Managers
  - Design team for High School (Bora Architects)
  - Design team for Middle School (Mahlum Architects)
- State Agencies
  - Oregon Emergency Management
  - Portland Metro Regional Solutions

Day-Long Stakeholder Workshop

Workshop at Tualatin Valley Fire & Rescue Command & Business Operations Center
February 10, 2015

Name	Participant's Affiliation
Jerry Abdie	KPFF Consulting Engineers
Bruce Barney	Portland General Electric
Aaron Boyle	Beaverton School District
Mike Britch	Tualatin Valley Water District
Brian Butler	Interface Engineering
David Chesley	Interface Engineering
Nate Cullen	Clean Water Services
Tiffany Delgado	Portland General Electric
David Etchart	Beaverton School District
Clint Fella	Oregon Office of Emergency Management
Karl Granlund	Beaverton School District
Jim Harold	Bora Architects
Scott Holum	Interface Engineering
Leslie Imes	Beaverton School District
Ruwan Jayaweera	PAE Engineers
Scott Johnson	Beaverton School District
Siobhan Kirk	Tualatin Valley Fire & Rescue
Michael Kummerman	NW Natural
Bobby Lee	Portland Metro Regional Solutions
Steve Muir	Washington County Emergency Management Cooperative
Michael Mumaw	City of Beaverton
Patrick O'Harrow	Beaverton School District
Curtis Peetz	American Red Cross
Scott Porter	Washington County Emergency Management Cooperative
Jeff Rubin	Tualatin Valley Fire & Rescue
Dick Steinbrugge	Beaverton School District
Brandon Watt	PAE Engineers
Dave Winship	City of Beaverton
Kurt Zenner	Mahlum Architects

New Middle School at Timberland

- **2-story**
- **165,000 SF**
- **1,100 Students**
- **$46M (Bldg. Hard Cost)**
- **Groundbreaking May 2015**
- **Completed July 2016**
- **Swing School for Replacements**

Structure Strategy

- Risk Category IV – Structural/Seismic Design
  - Code Requirement – Category III

- Non-structural Components
  - Equipment (required to operate after EQ) seismically certified
  - Components required for use as shelter: Category IV seismic bracing
  - Others: Category III seismic bracing

Structural Typical Braced Frame

Water & Waste Water Strategy

- Restrained pipe joints between city lines and building
- Stub-out water connections for exterior tanker supply:
  - Kitchen
  - Locker rooms & showers
  - Drinking fountains in common spaces
  - Restrooms serving dining / commons
- Seismic bracing of building plumbing per Category IV
- Short Term: Others to provide portable toilets

Power & HVAC Strategy

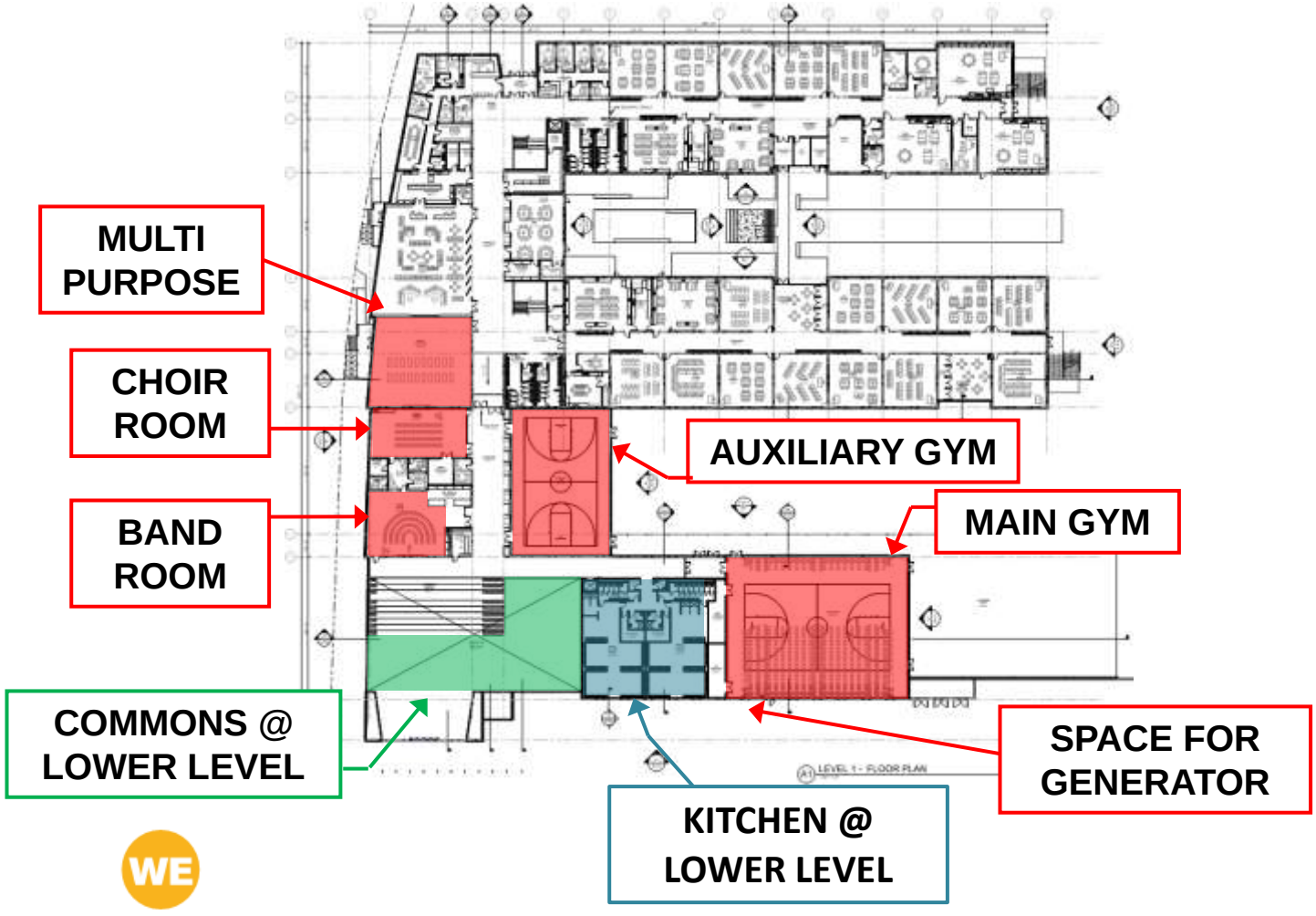
- Emergency Power
  - 500 KW generator; 96-hour fuel storage
  - Supplemented with solar PV system
  - Power for lighting and ventilation in entire school

- Heating & Cooling
  - Assume no natural gas service: jackets / blankets
  - Natural ventilation: doors, windows, and exhaust fans

Gas & Telecom Strategy

- Natural Gas
  - Seismic shut-off valve to reduce potential fire hazard
- Telecommunication
  - Emergency Management agencies to bring in portable communication systems
  - Beaverton School District radio system

New Middle School



Added Cost: ~ 1.7% of Building

Middle School Resilience Features		Cost Estimate
	Design building structure's lateral-force resisting system for seismic Risk Category IV	$310,000
	Provide 500 kW emergency generator with 96-hour run time fuel storage. Emergency generator, switch gear, ventilation fans, and other equipment that is expected to be operational after an earthquake should satisfy the special certification requirements of ASCE 7-10, which is referenced by the OSSC	$400,000
	Provide electrical service to power lighting and ventilation fans in common areas and gymnasium on emergency power; heating is only provided for the commons, gymnasium, administrative wing and locker room area, does not provide conditioned air	Included in Total
	Provide quick-connect stub-outs at building exterior to allow use of portable water tank and associated pump to supply water to key building areas: kitchen, locker rooms & showers, and drinking fountains in common spaces	$20,000
	Provide two electrical outlets in kitchen on emergency power to allow hot plates for water boiling, etc.	$5,000
	Provide natural gas seismic shutoff valve at meter	Negligible
	Provide hardened water service line from TVWD water line to building	TBD
	Provide hardened sanitary sewer service line from CWS sewer line to building	TBD
	Provide seismic bracing/anchorage design of nonstructural components based on Risk Category III requirements except that those components required for use of the school as emergency shelter (as specified in Sections 6.5 and 6.6) satisfy Risk Category IV requirements	Negligible
	Approximate Total	**$750,000**

Project Challenges

- Budget Challenge
  - No allowance for resilience features in original budget
  - Lack of financial partners
- Schedule Challenge
  - Design team started a few months before resilience planning consultants were retained
  - Resilience features finalized by end of SD phase

Key Elements for Project Success

- Vision and Leadership
  - Internal Champion and advocates
  - Board’s Support
- Project Managers and Design Teams
  - Internal Engagement
- Community Stakeholders
  - External Engagement

Questions & Follow-up

Kent Yu, PhD, PE, SE
Email: kentyu@seftconsulting.com
Phone: (503)702-2065

Richard Steinbrugge, PE
Email: Richard_Steinbrugge@beaverton.k12.or.us
Phone: (503) 356-4449

New Beaverton Middle School a more resilient community

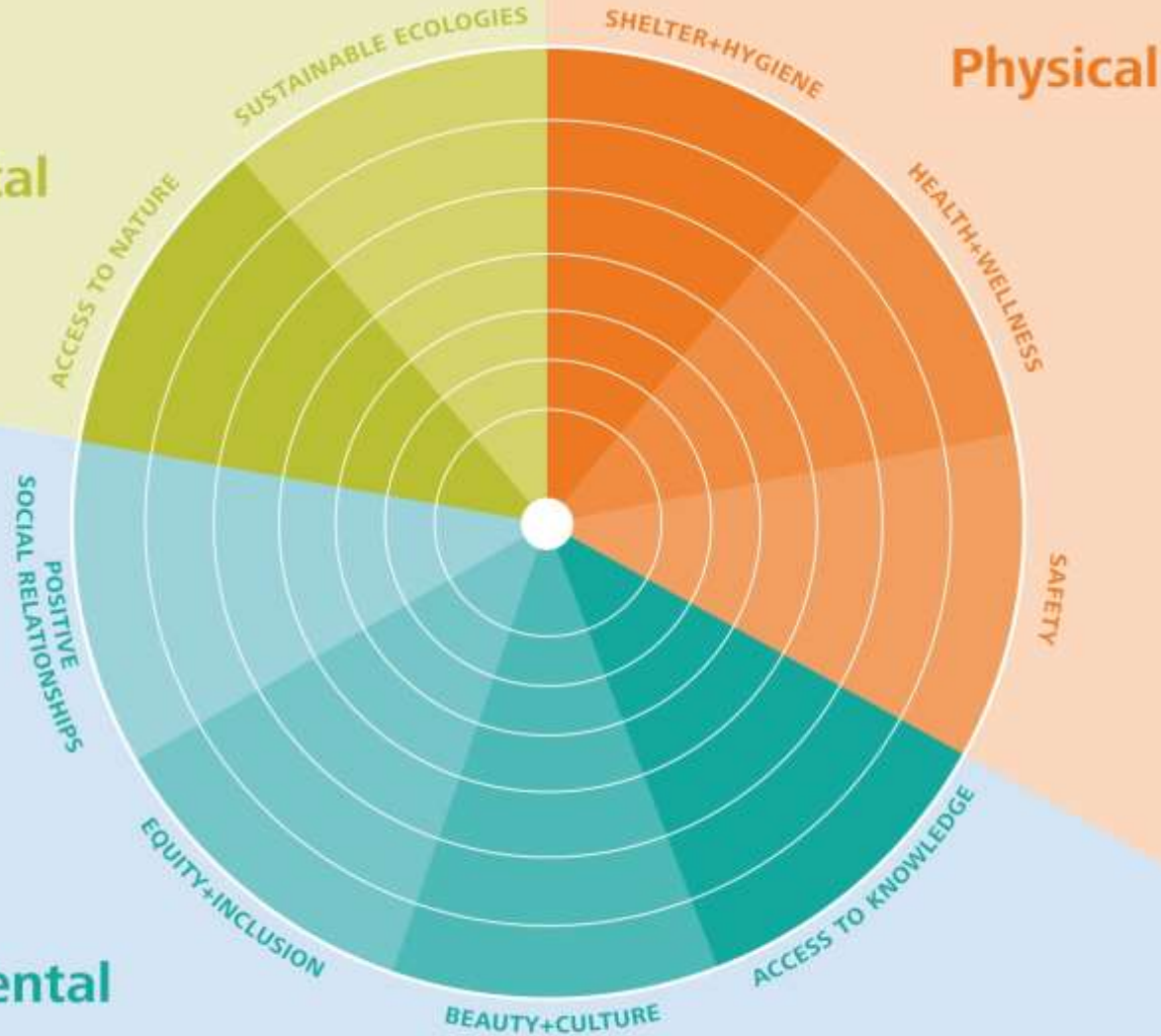
Kurt Zenner AIA LEED AP

mahlum

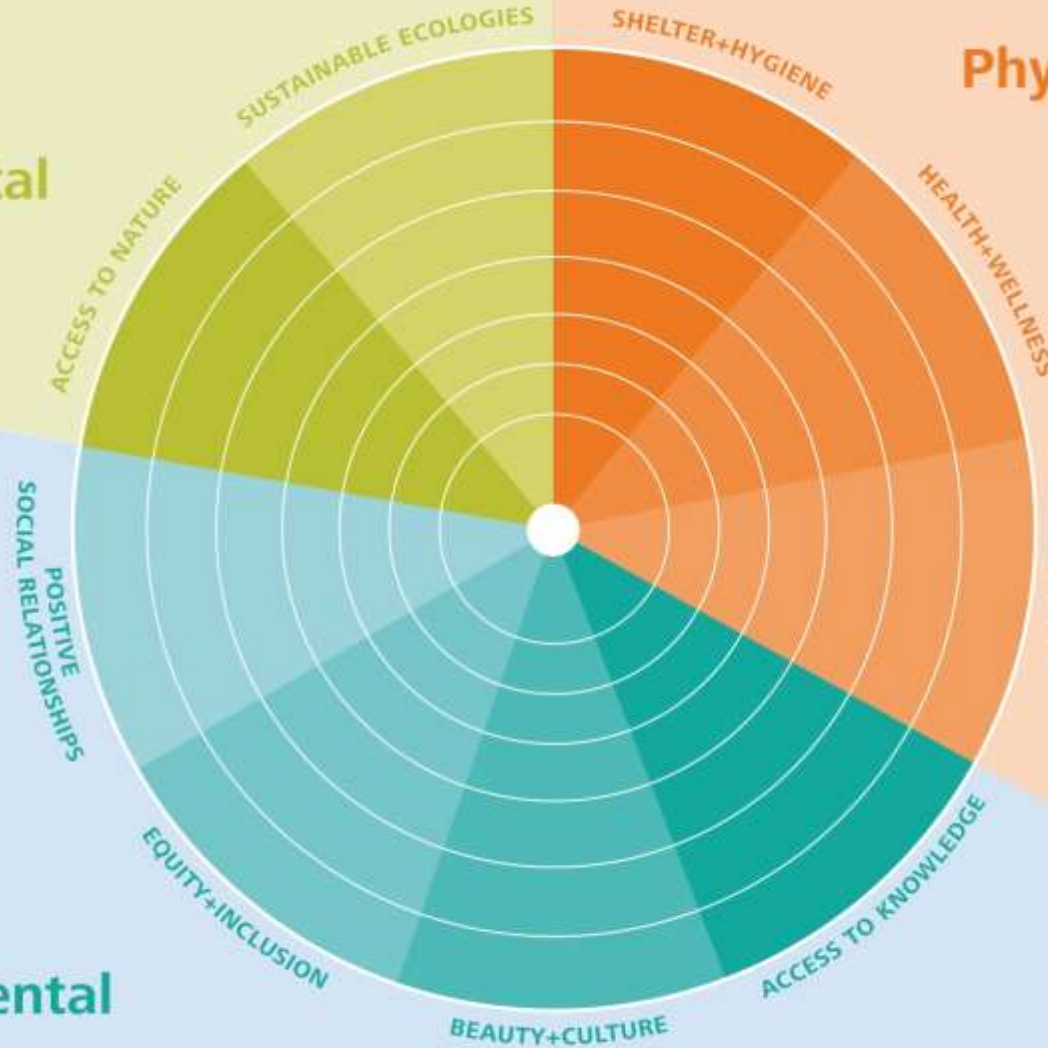

stryker
EMERGENCY


OREGON
STATE

Mahlum is committed to creating healthy and enduring communities to support the lives of future generations.



Mahlum is committed to creating healthy and enduring communities to support the lives of future generations.



New Beaverton Middle School

mahlum

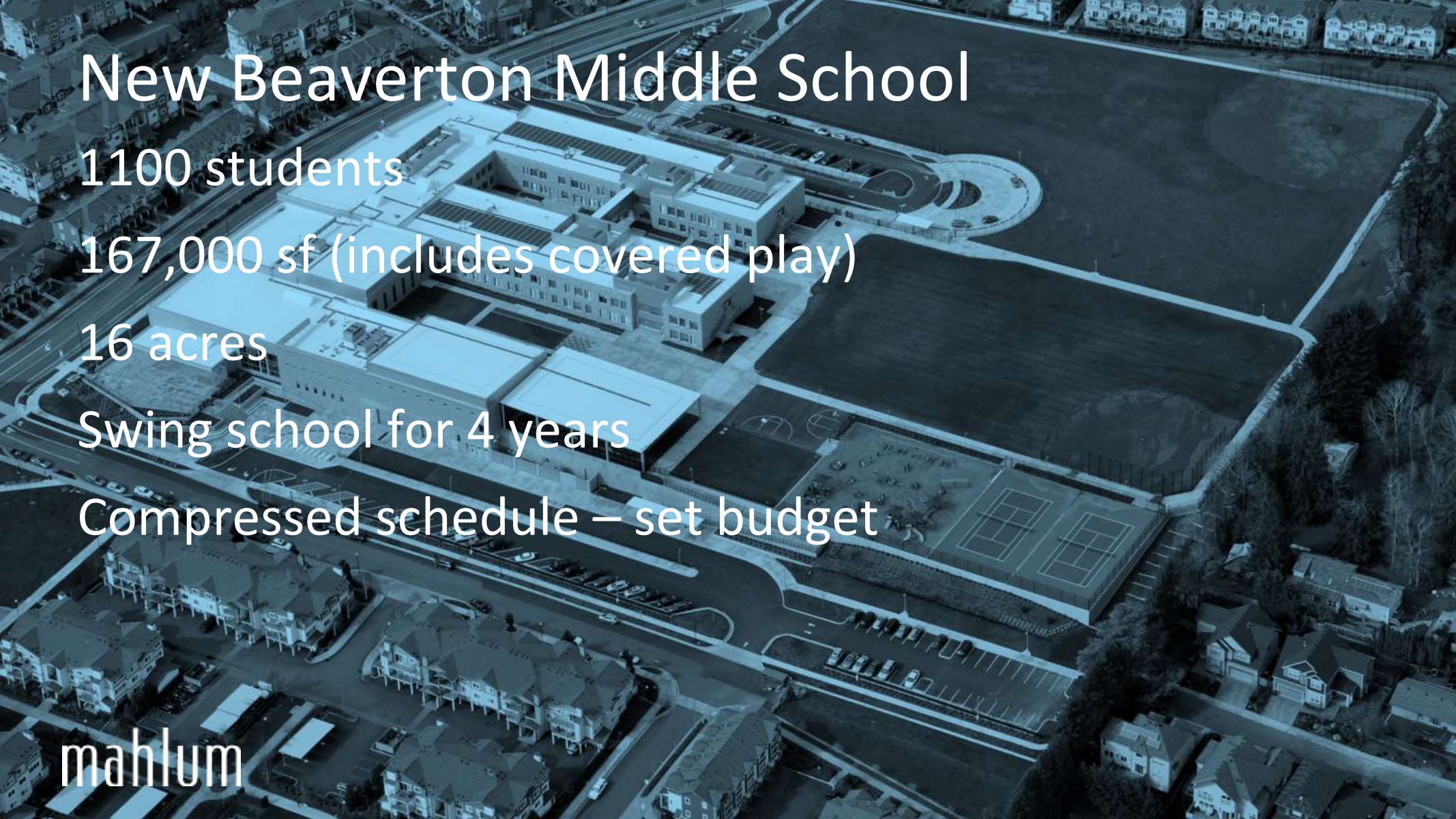
New Beaverton Middle School

1100 students

167,000 sf (includes covered play)

16 acres

mahlum



New Beaverton Middle School

1100 students

167,000 sf (includes covered play)

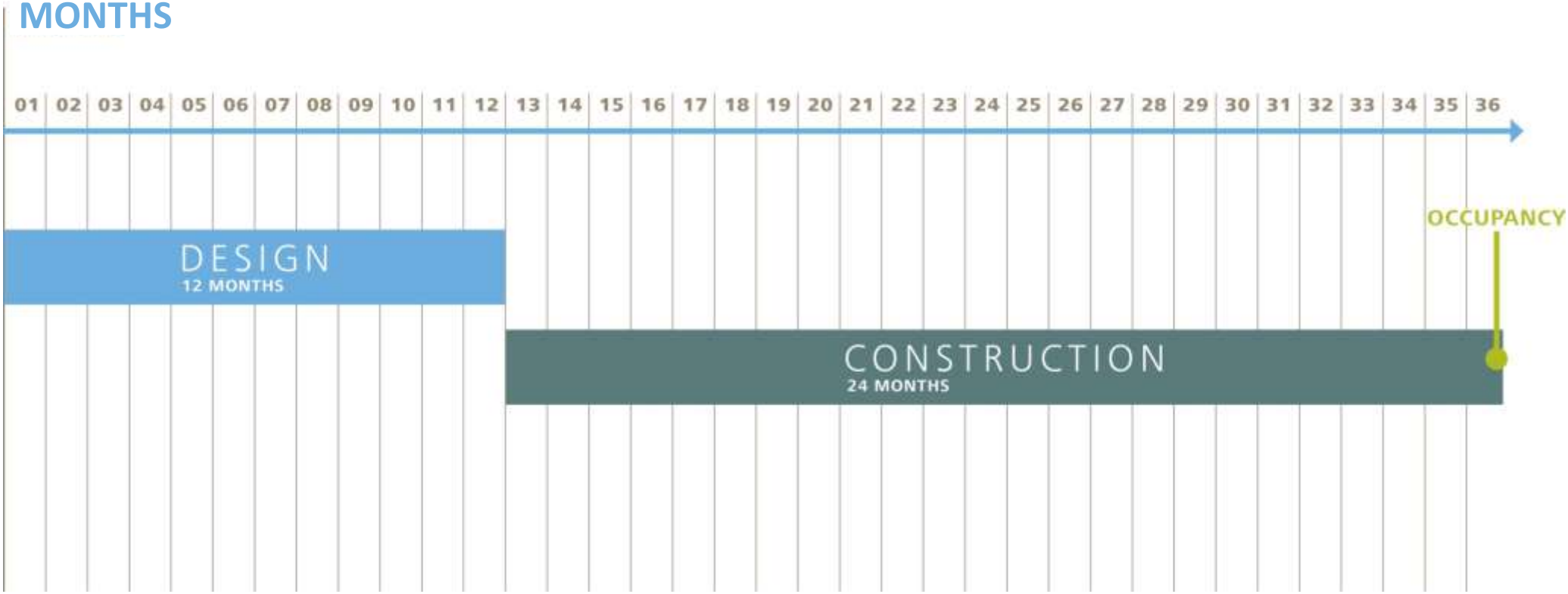
16 acres

Swing school for 4 years

Compressed schedule – set budget

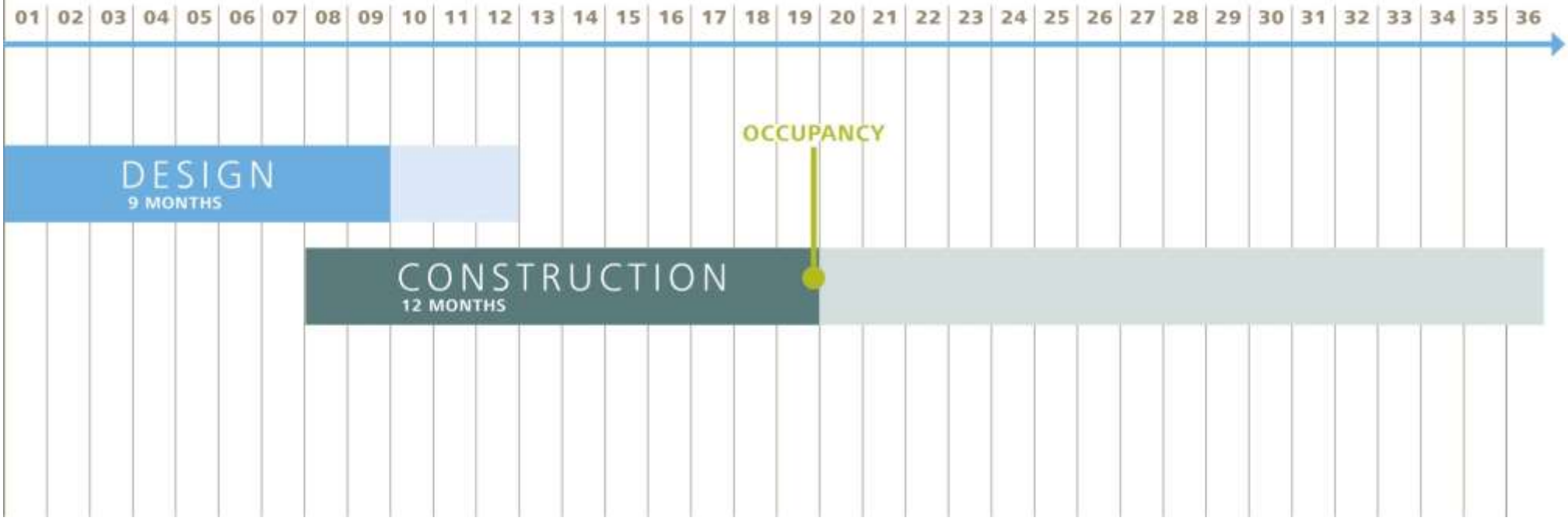
mahlum

Typical Schedule

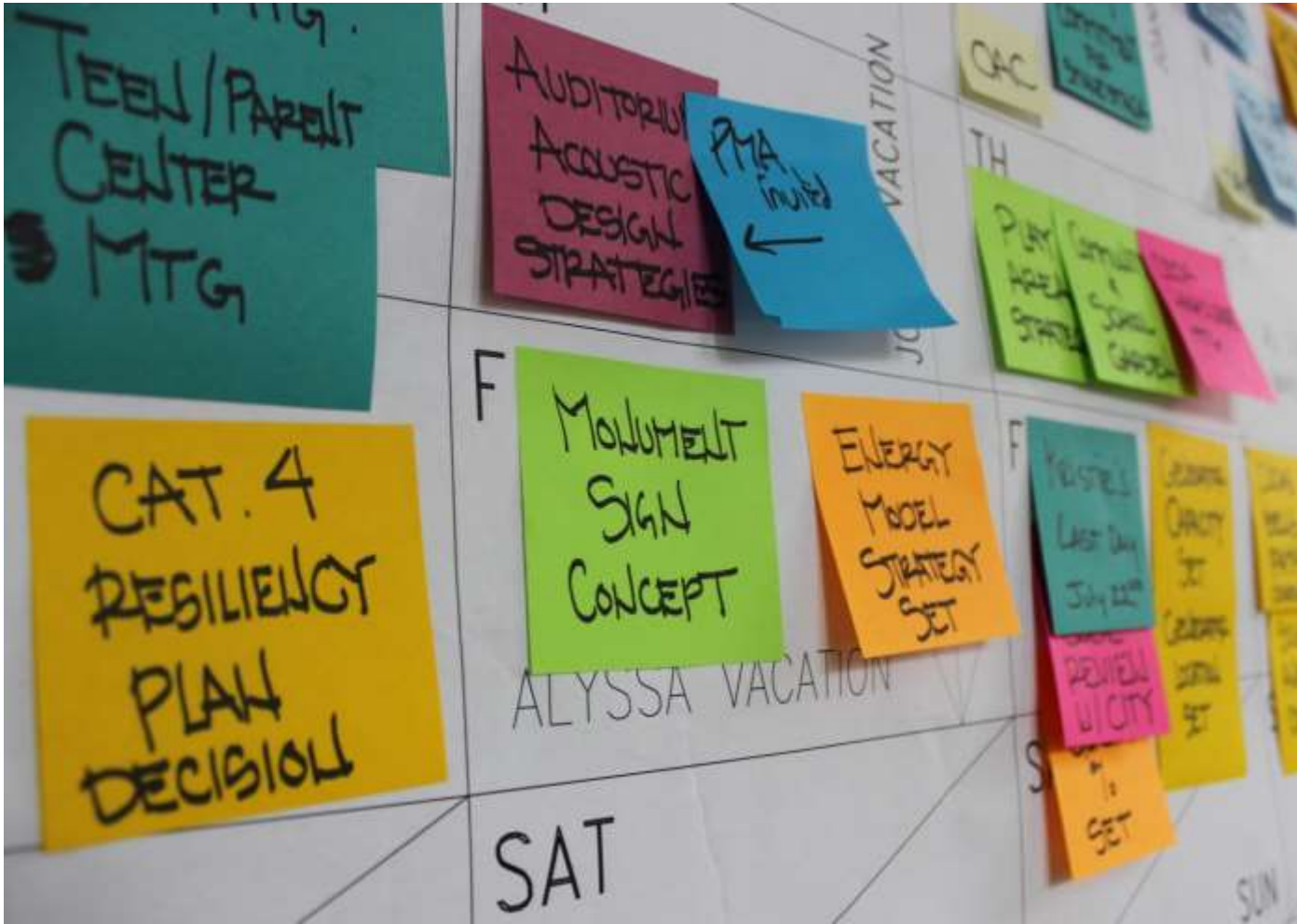


Schedule

MONTHS



Integrated Design



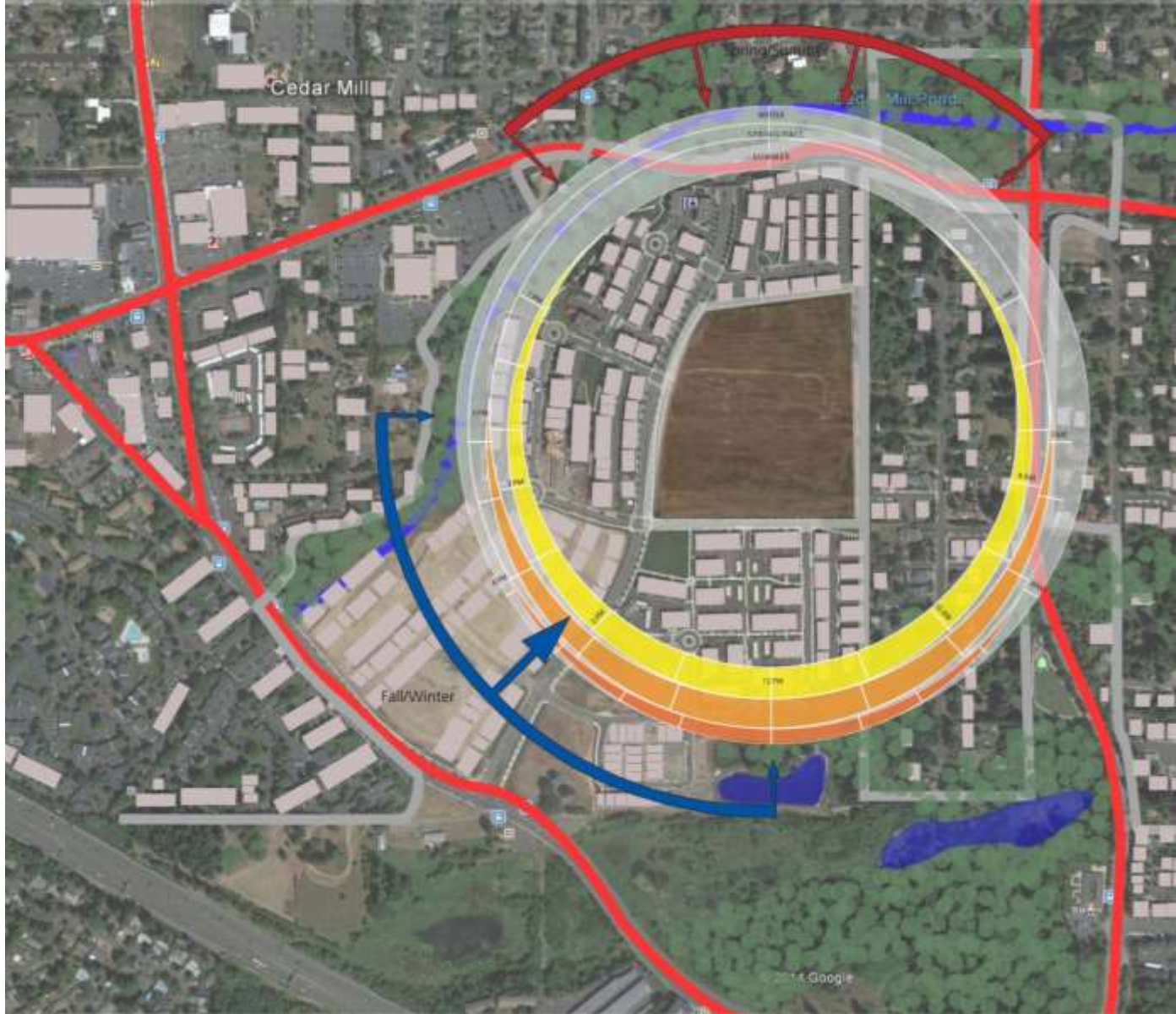
Site Analysis

Solar Access

Daylighting

Winter winds

Neighborhood connections



Design Review

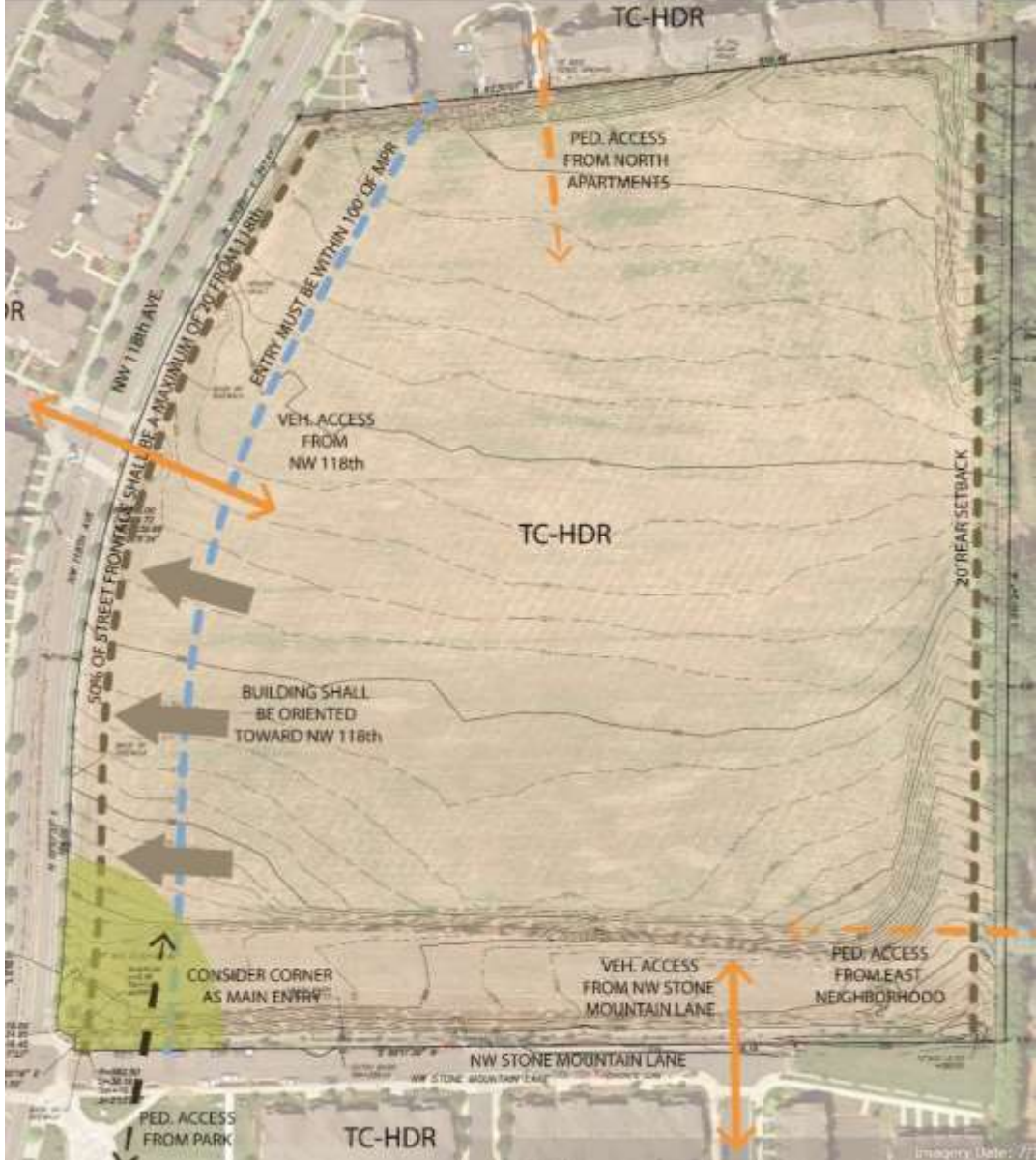
CITY OF BEAVERTON

Building orientation

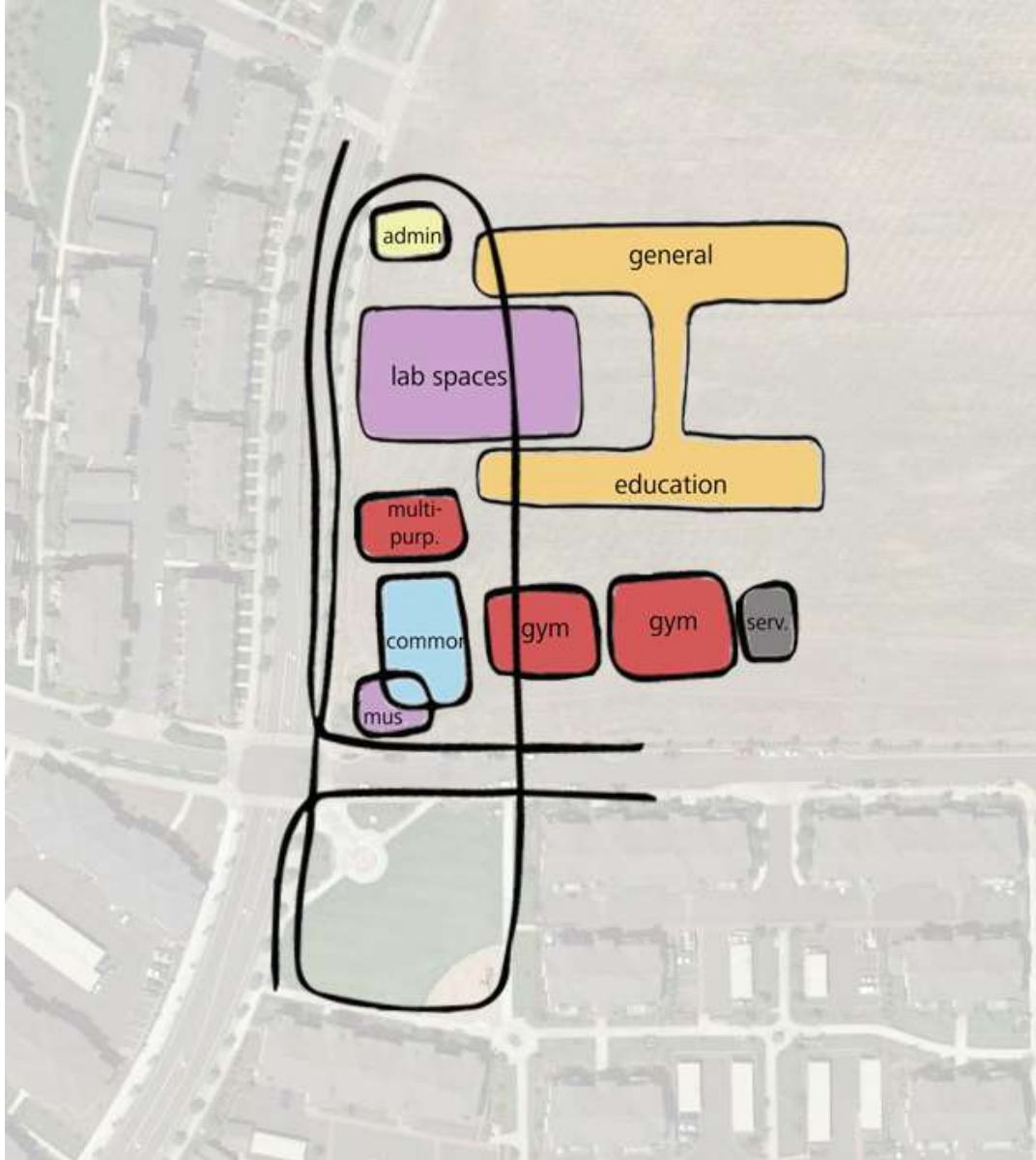
Vehicular access

Pedestrian connectivity

Site topography

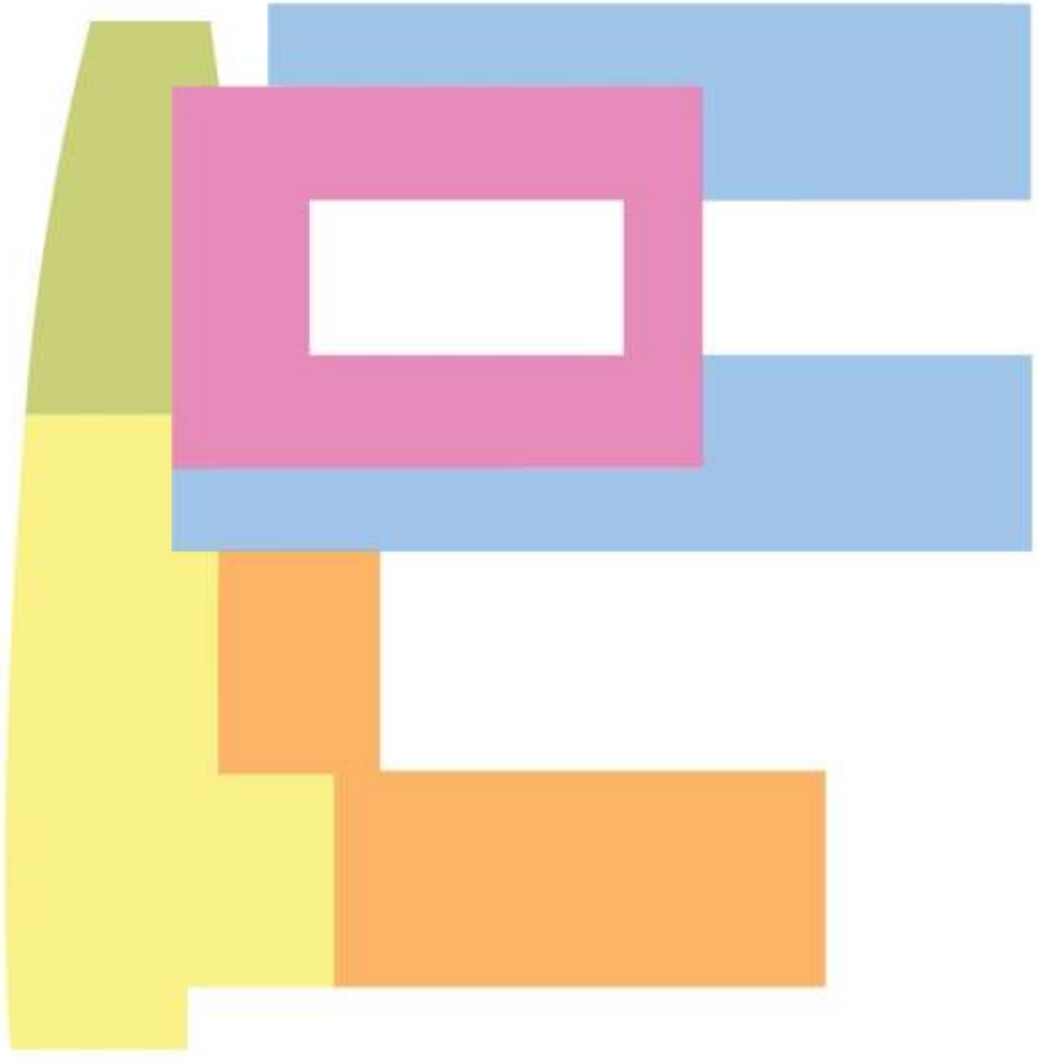


Conceptual Program Zoning Studies



MS Program

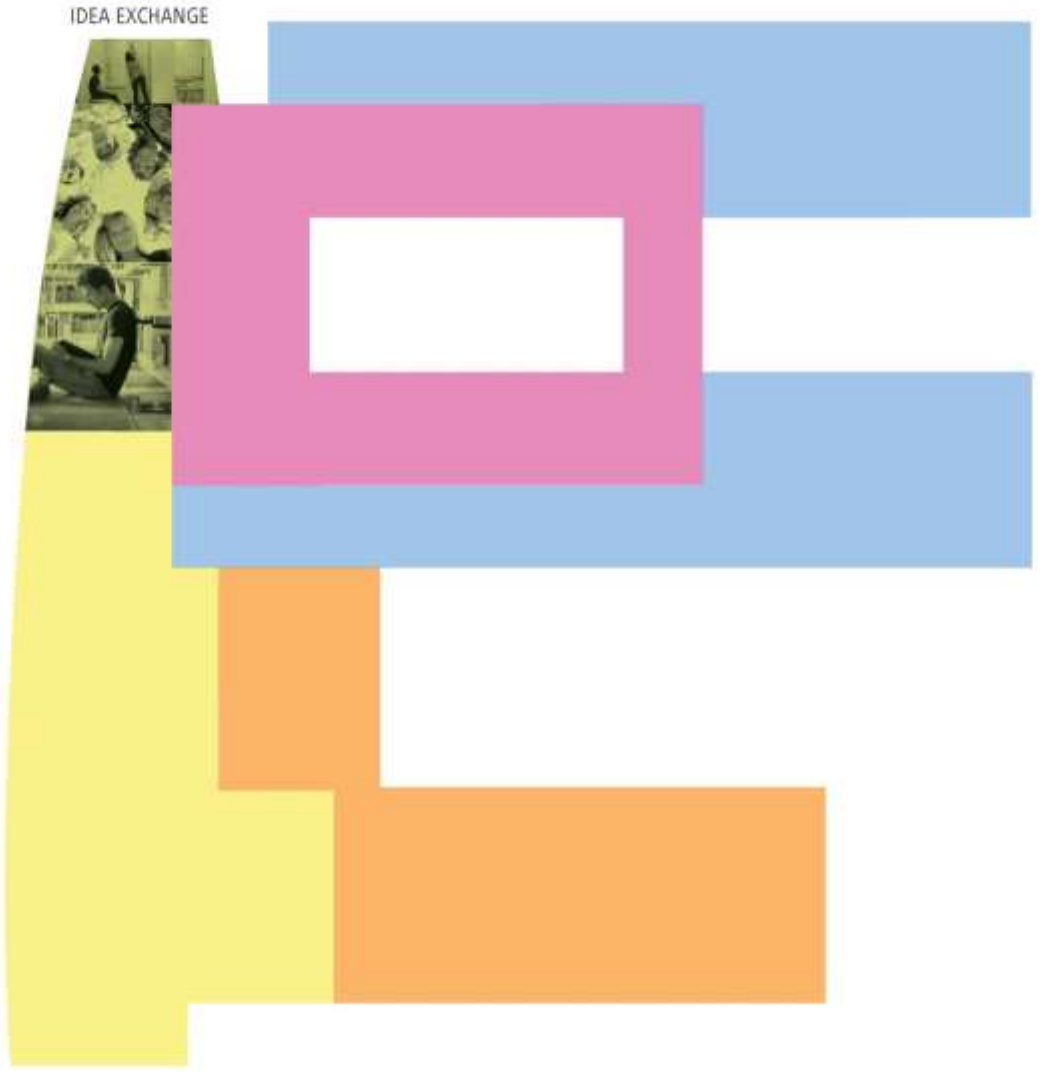
BUILDING BLOCKS OF LEARNING



MS Program

BUILDING BLOCKS OF LEARNING

Idea Exchange

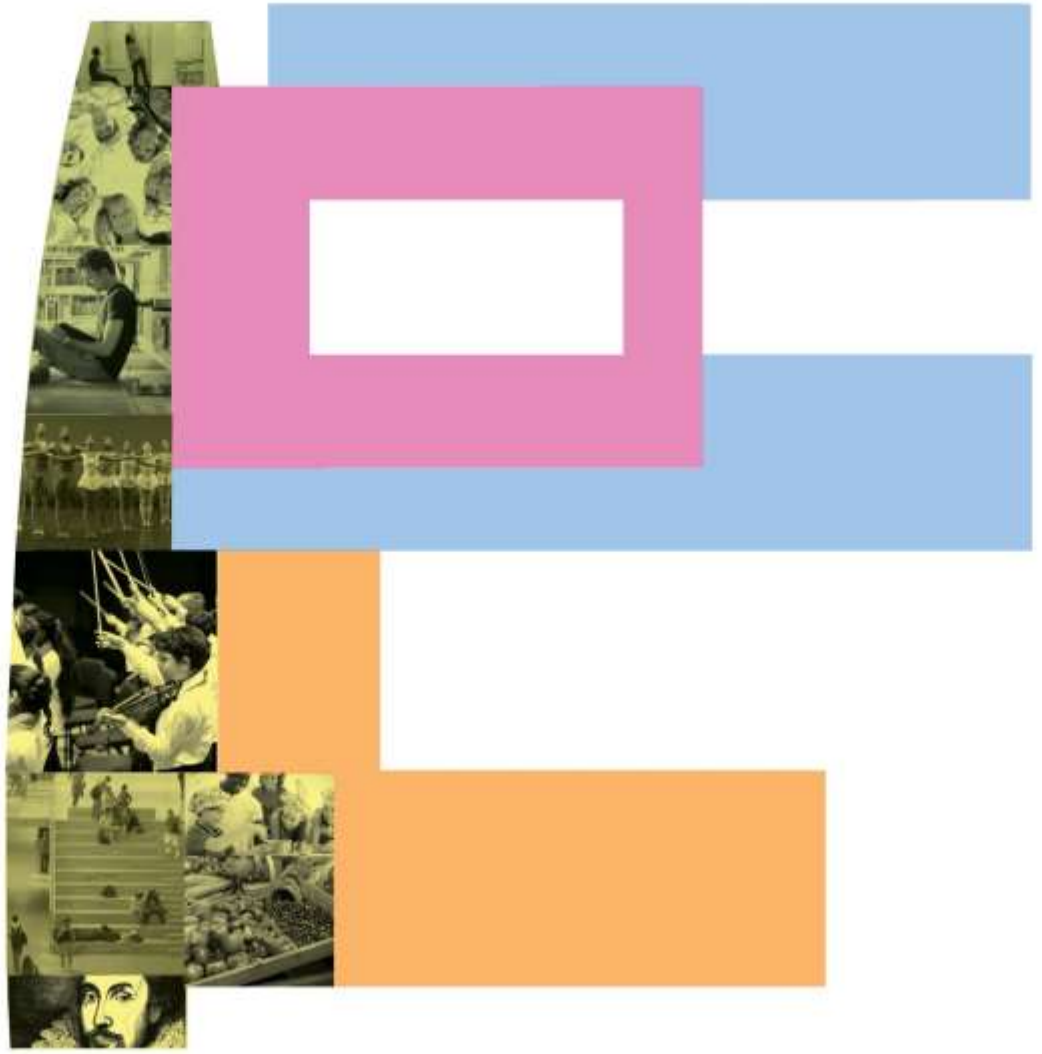


MS Program

BUILDING BLOCKS OF LEARNING

Idea Exchange

Culture Hub



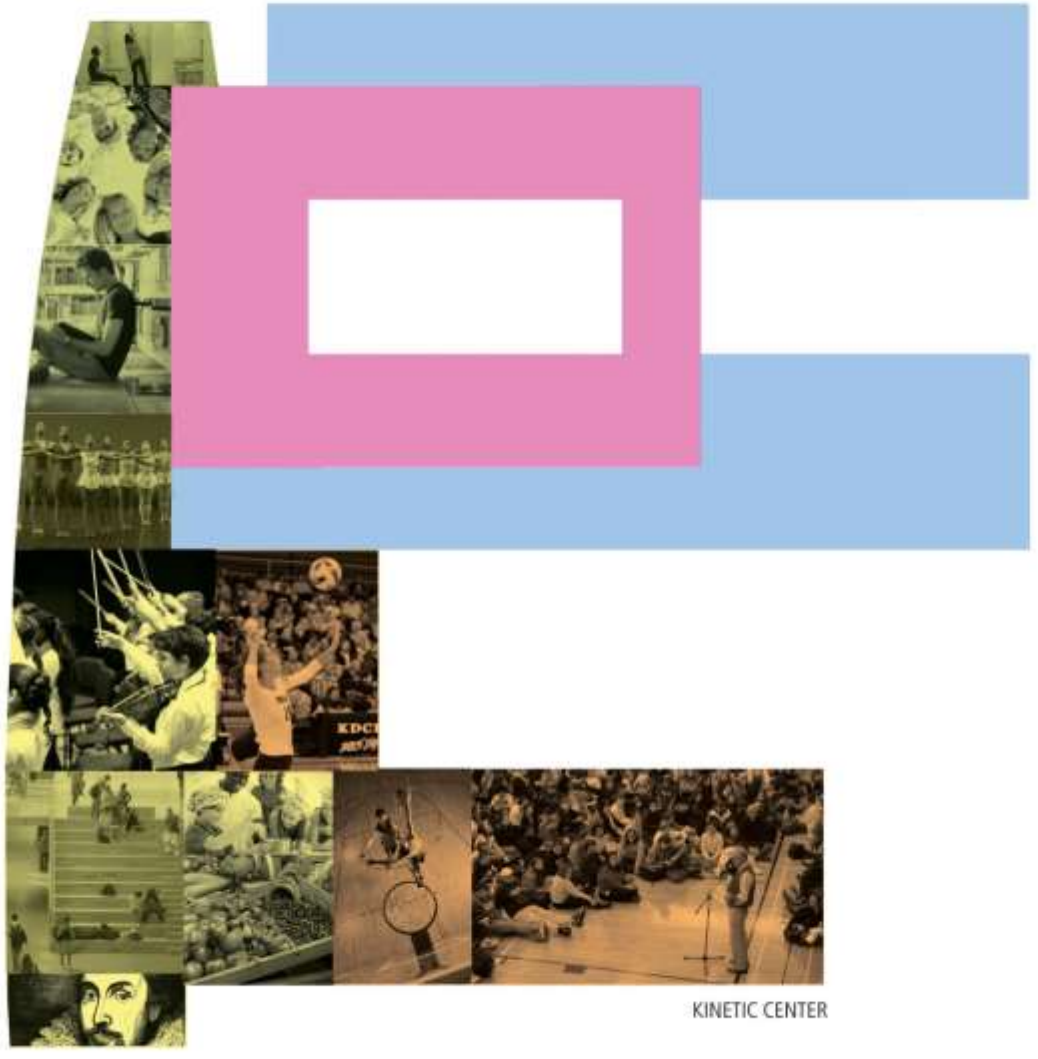
MS Program

BUILDING BLOCKS OF LEARNING

Idea Exchange

Culture Hub

Kinetic Center



MS Program

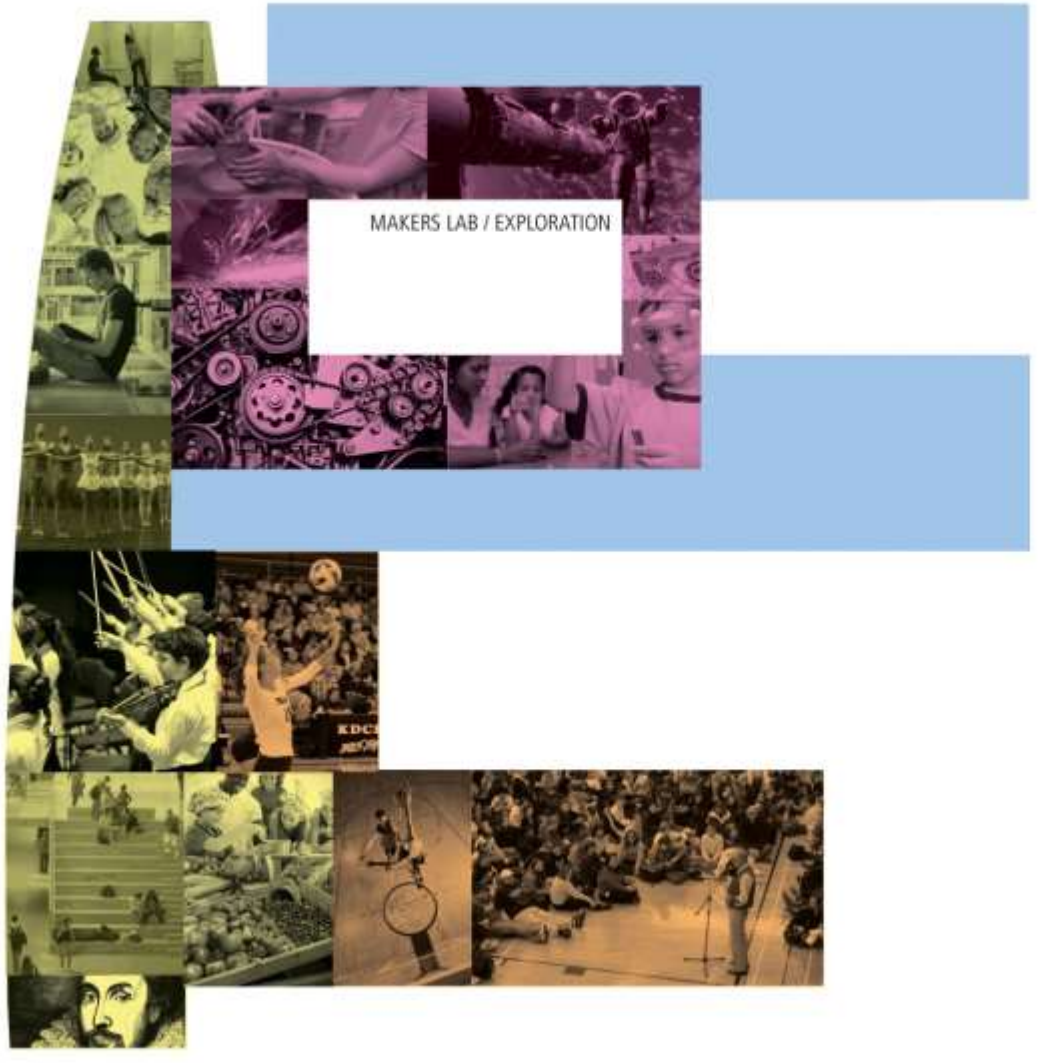
BUILDING BLOCKS OF LEARNING

Idea Exchange

Culture Hub

Kinetic Center

Maker’s Lab / Exploration



MS Program

BUILDING BLOCKS OF LEARNING

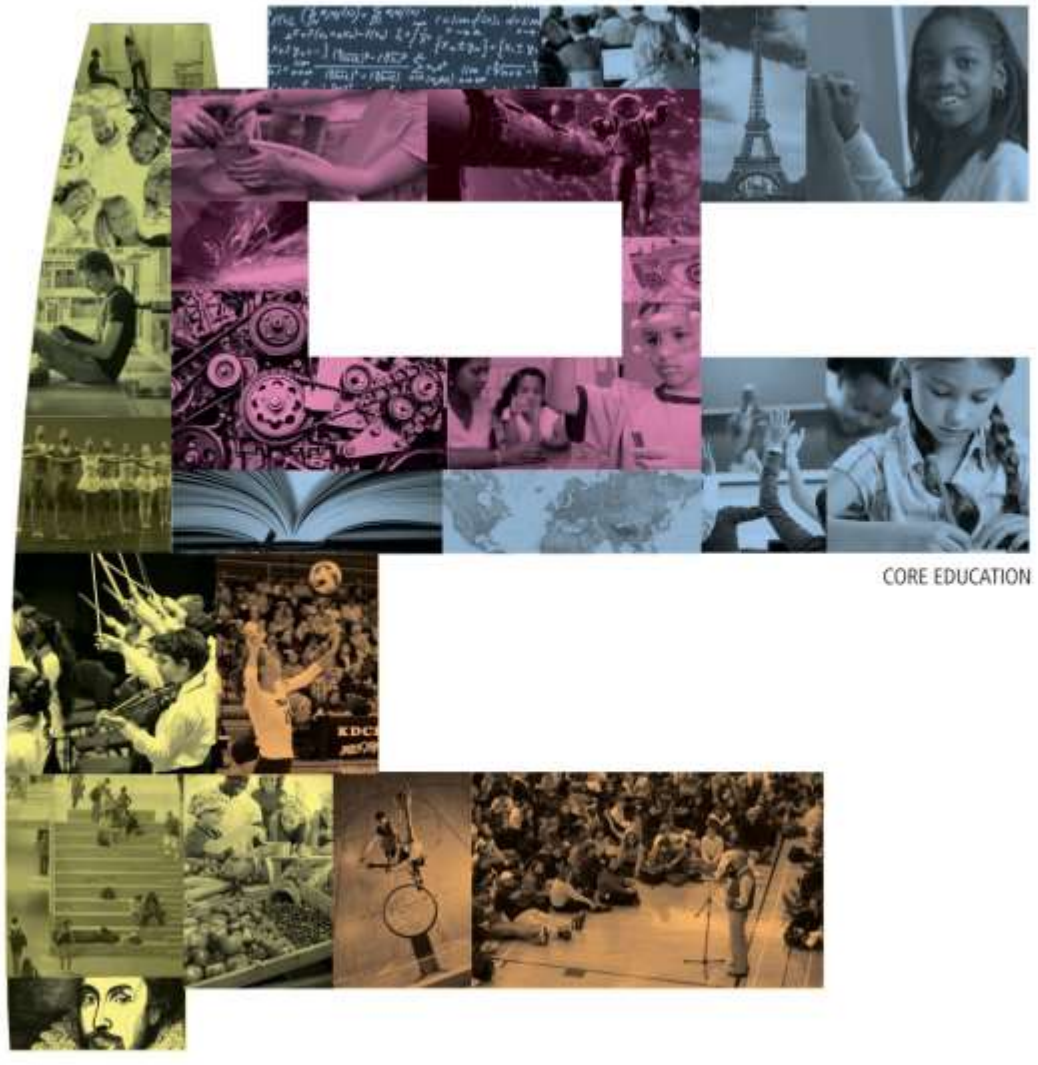
Idea Exchange

Culture Hub

Kinetic Center

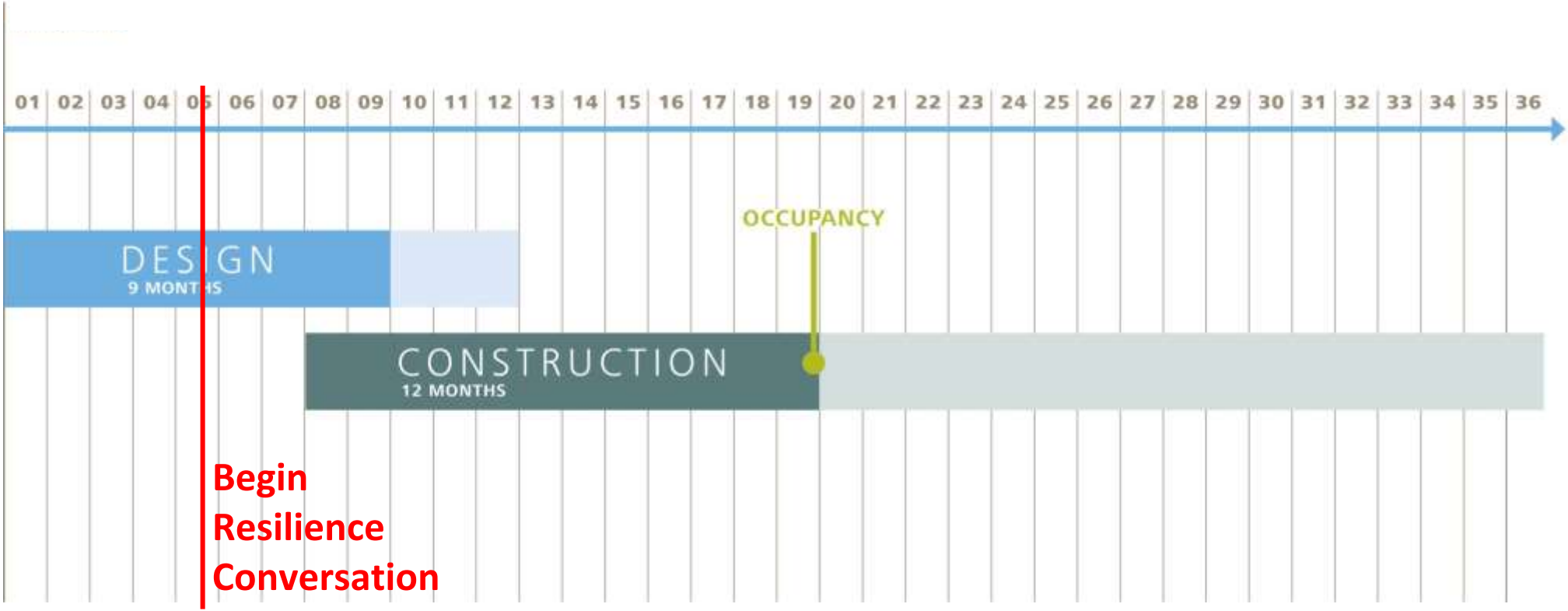
Maker’s Lab / Exploration

Core Education



Schedule

MONTHS



Resilience

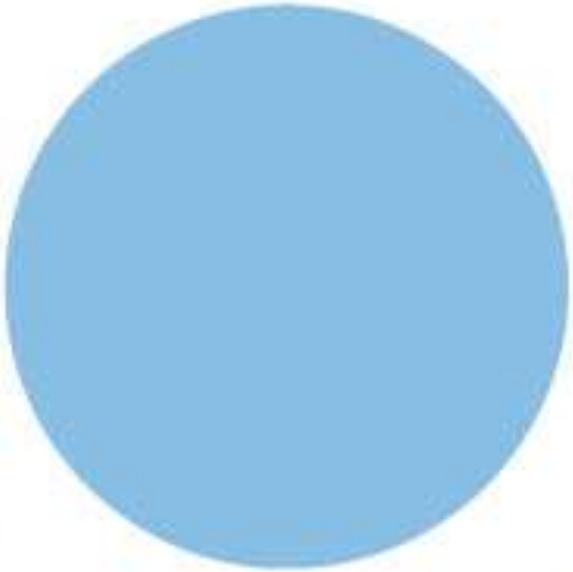
BEAUTY

Resilience

THREATS

What is a school?

Resilience



CODE
Health + Safety

ENERGY EFFICIENCY
Conserving Resources

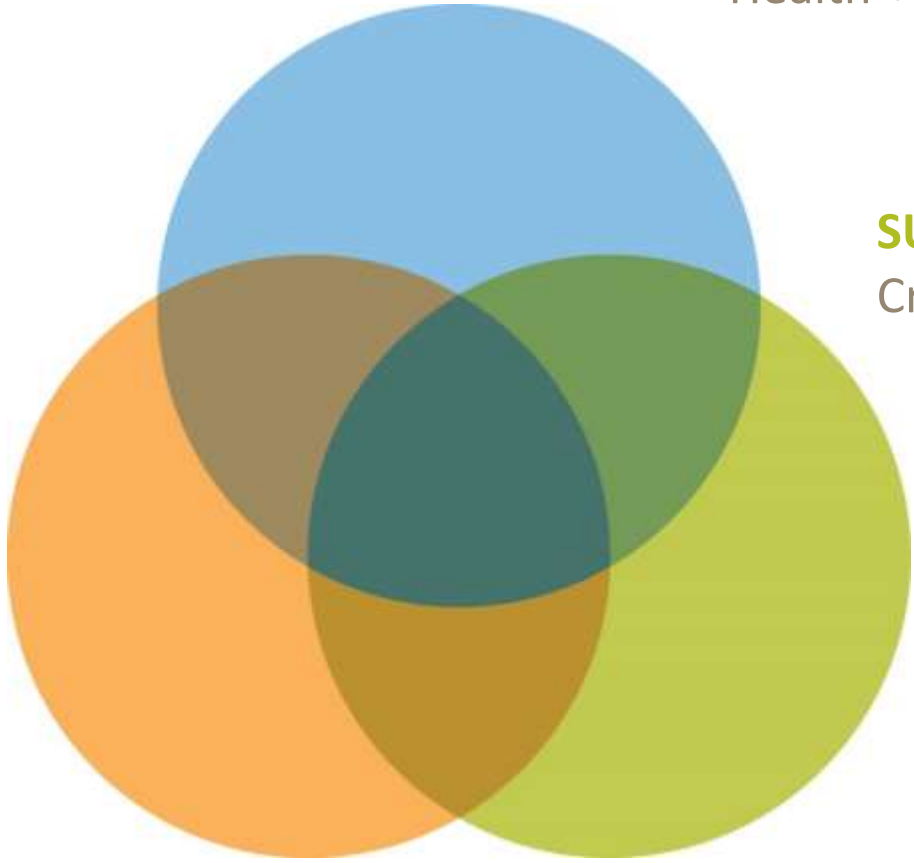
SUSTAINABILITY
Cradle to Cradle

Resilience

CODE
Health + Safety

ENERGY EFFICIENCY
Conserving Resources

SUSTAINABILITY
Cradle to Cradle



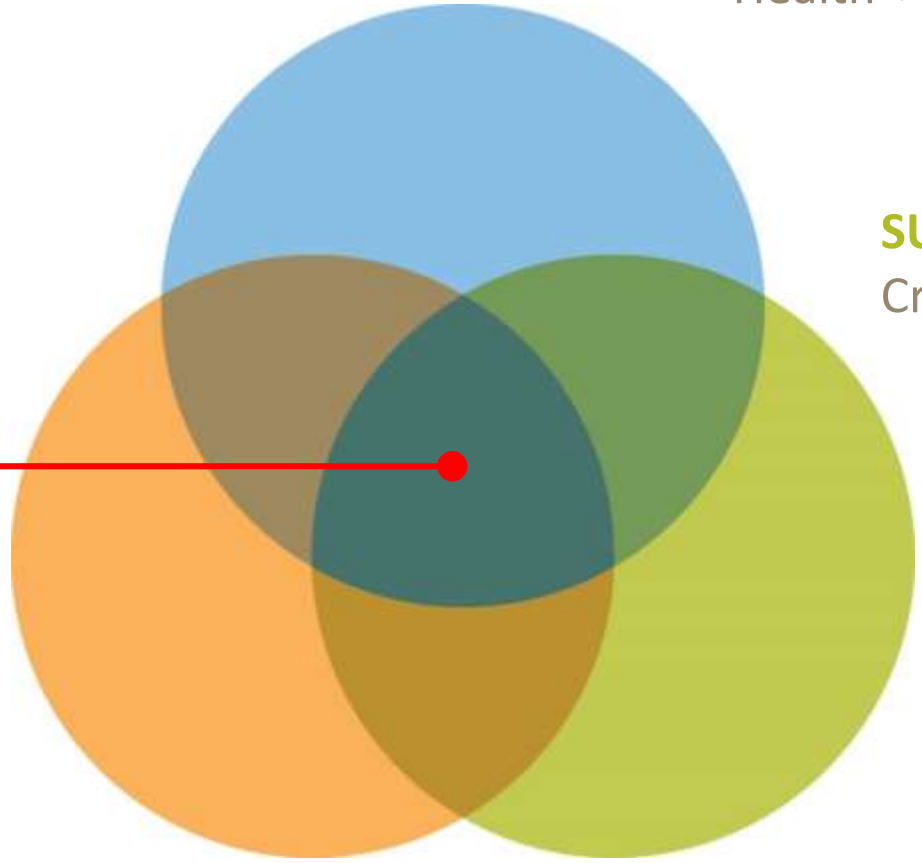
Resilience

CODE
Health + Safety

ENERGY EFFICIENCY
Conserving Resources

SUSTAINABILITY
Cradle to Cradle

RESILIENCE




Resilience Planning
Shelter
Water
Food
Power
Communications
mahlum

Resilience Planning

SHELTER

Structural Integrity

Primary Structure : Category IV
Essential Equip.: seismically certified
Essential Equip. + plumbing: Category IV
Other non structural items: Category III

Water & Waste

Strengthened connections to Providers
Potable Water connection
Portable Toilets by others

Power

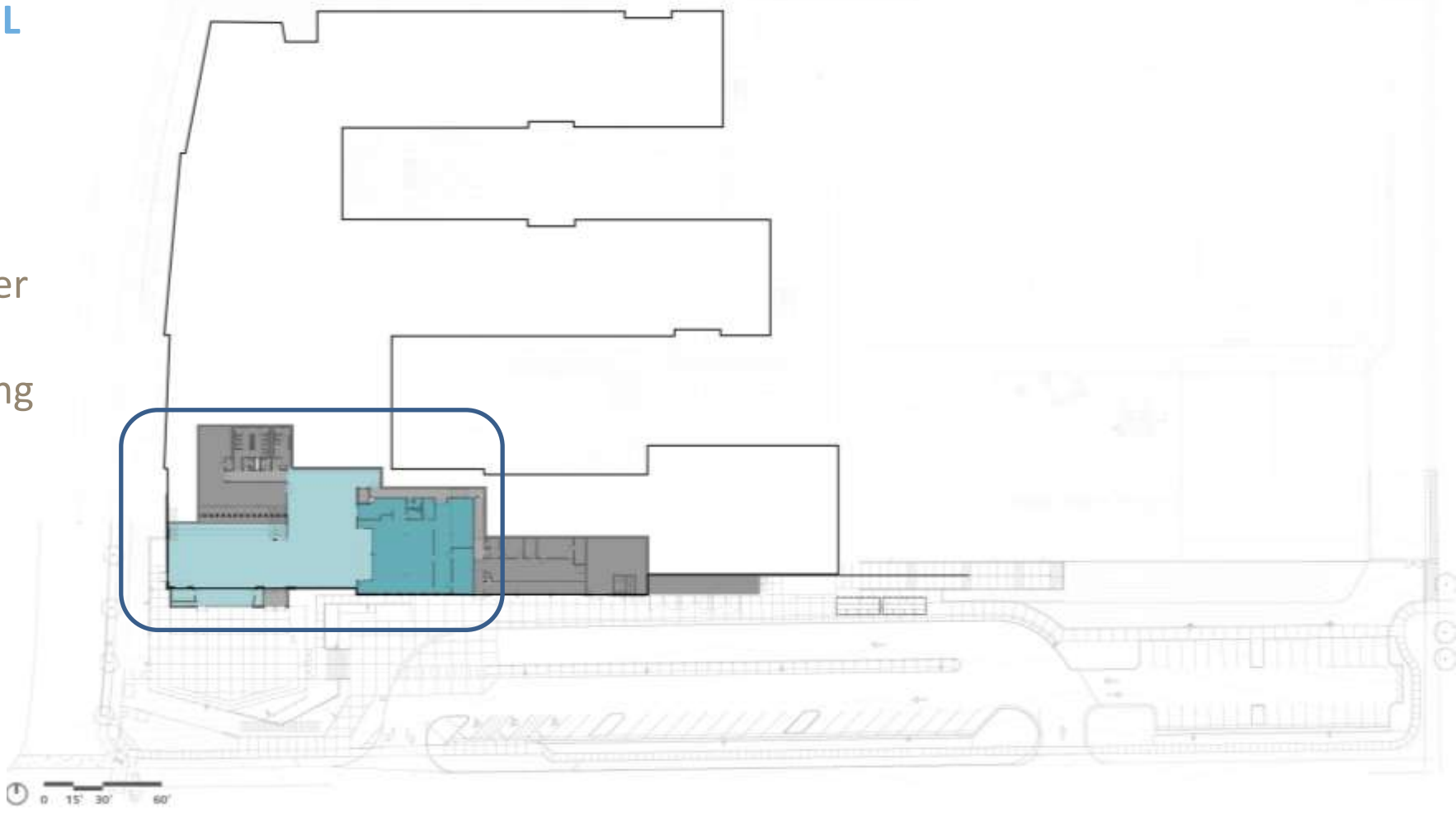
500 kW Generator
4000 gal fuel supply ~ RT 96hrs

Resilience Planning

LOWER LEVEL

Community

Ventilation
Lighting
Limited Power
Hot Water
Food Warming

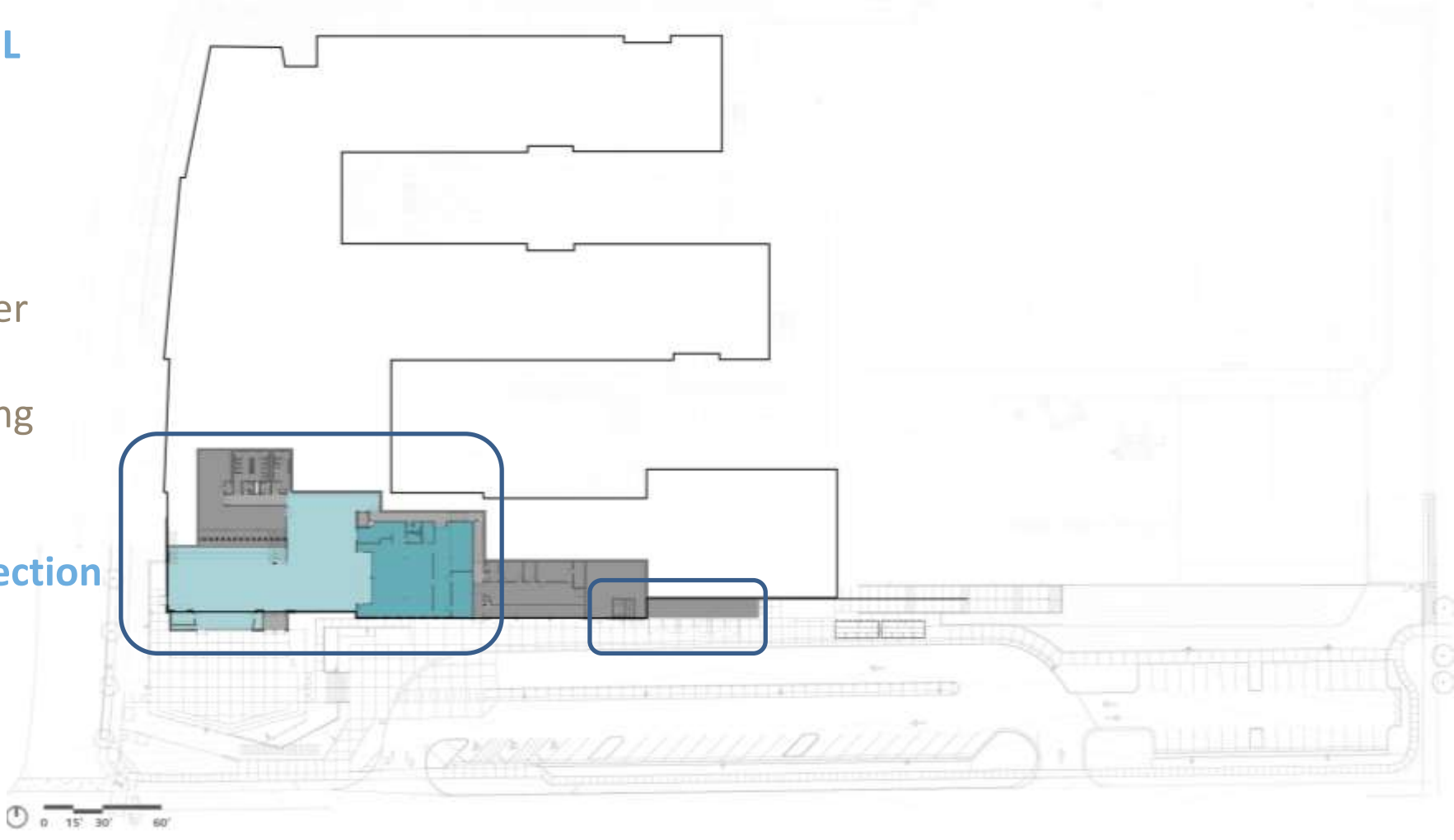


Resilience Planning

LOWER LEVEL

Community
Ventilation
Lighting
Limited Power
Hot Water
Food Warming

Generator
Water Connection



Resilience Planning

FIRST FLOOR

Main Shelter Areas

Ventilation
Lighting
Limited Power

0 15' 30' 60'

Resilience Planning

FIRST FLOOR

Main Shelter Areas
Ventilation
Lighting
Limited Power

Main Office
Communications
Lighting
Limited Power
LAN
Security

Resilience Planning

FIRST FLOOR

Main Shelter Areas
Ventilation
Lighting
Limited Power

Main Office
Communications
Lighting
Limited Power
LAN
Security

FIRST FLOOR

Aux Shelter Areas
Operable Windows
Emergency Lighting

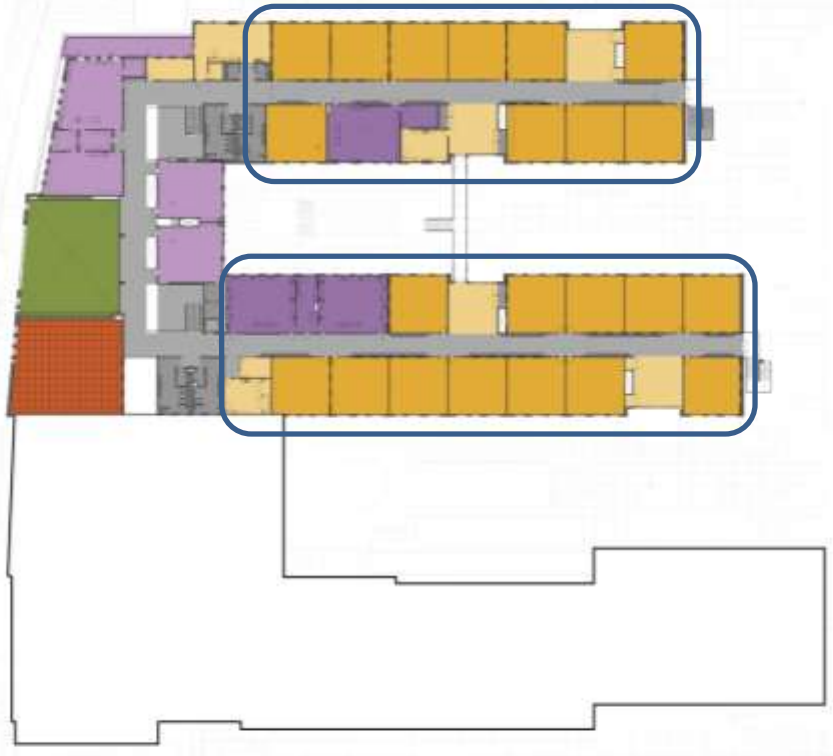
Resilience Planning

SECOND FLOOR

Aux Shelter Areas

Operable Windows

Emergency Lighting



0 15' 30' 60'

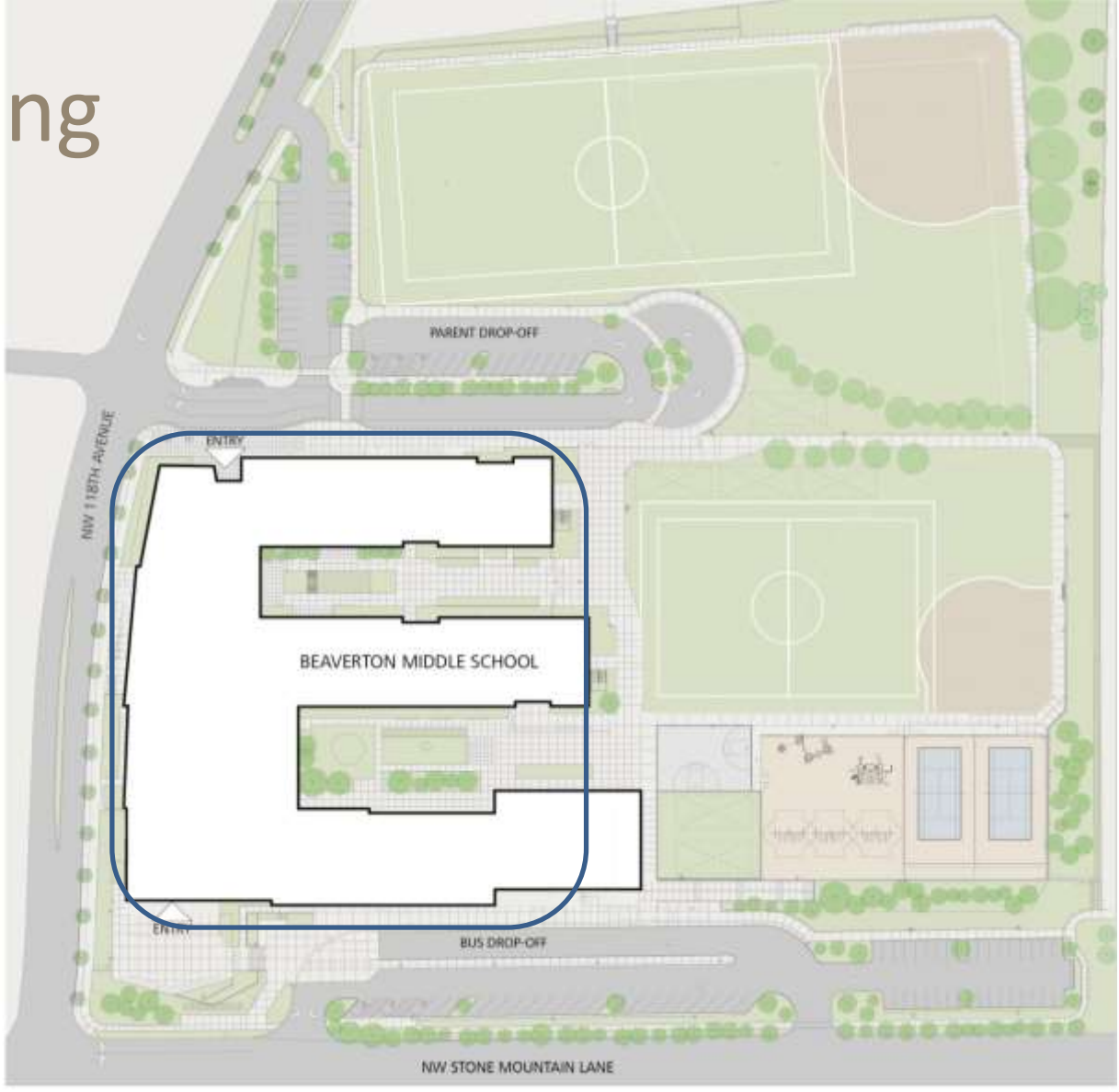
Resilient Planning

Site Strategy

Immediate Use

Students/Staff

96+ hrs



5' 50' 100'

Resilient Planning

Site Strategy

Immediate Use

Students/Staff

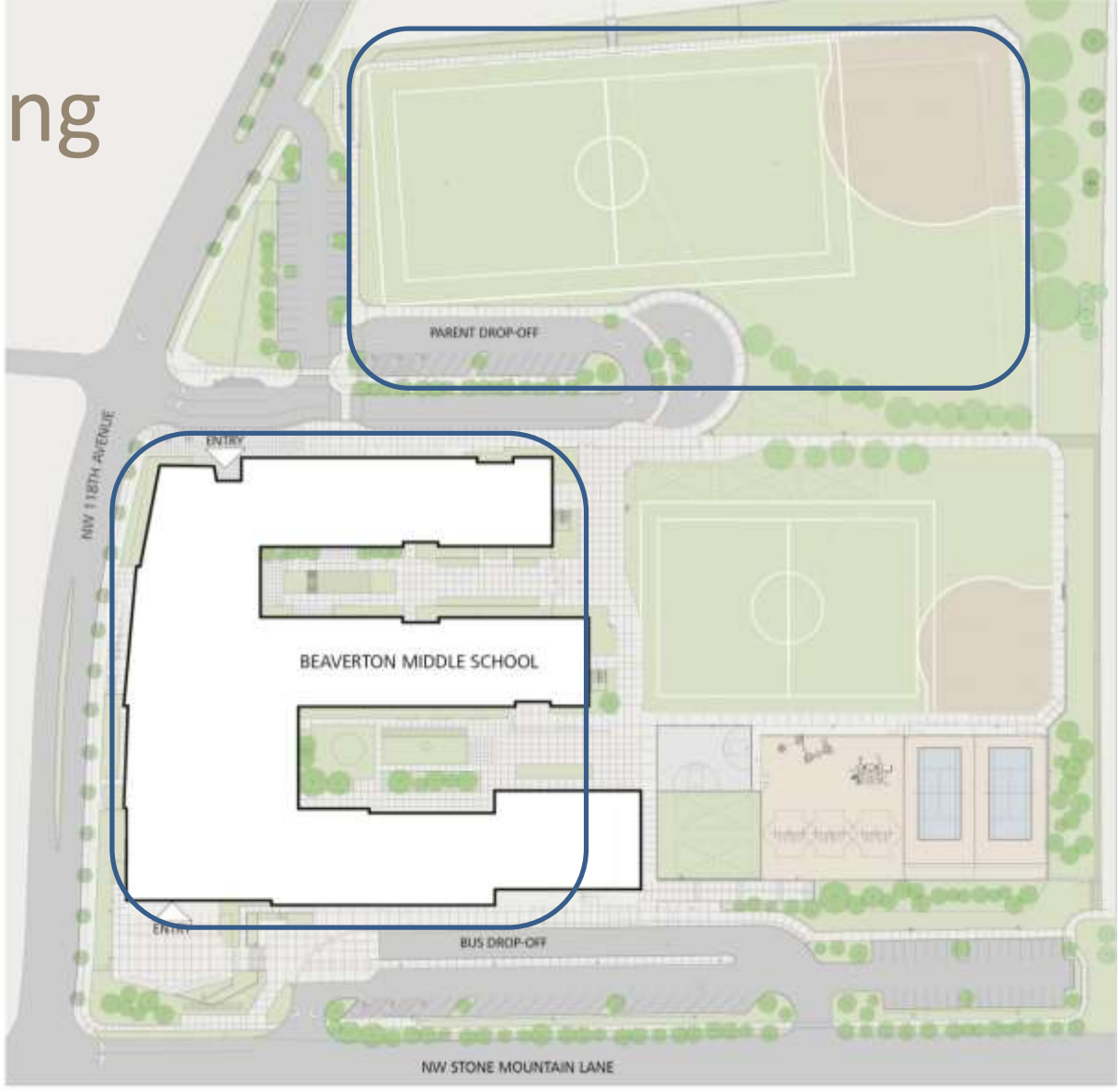
96+ hrs

3 - 30 days

Community Shelter

Distribution Center

Camp Area



5' 50' 100'

Resilient Planning

Site Strategy

Immediate Use

Students/Staff

96+ hrs

3 - 30 days

Community Shelter

Distribution Center

Camp Area

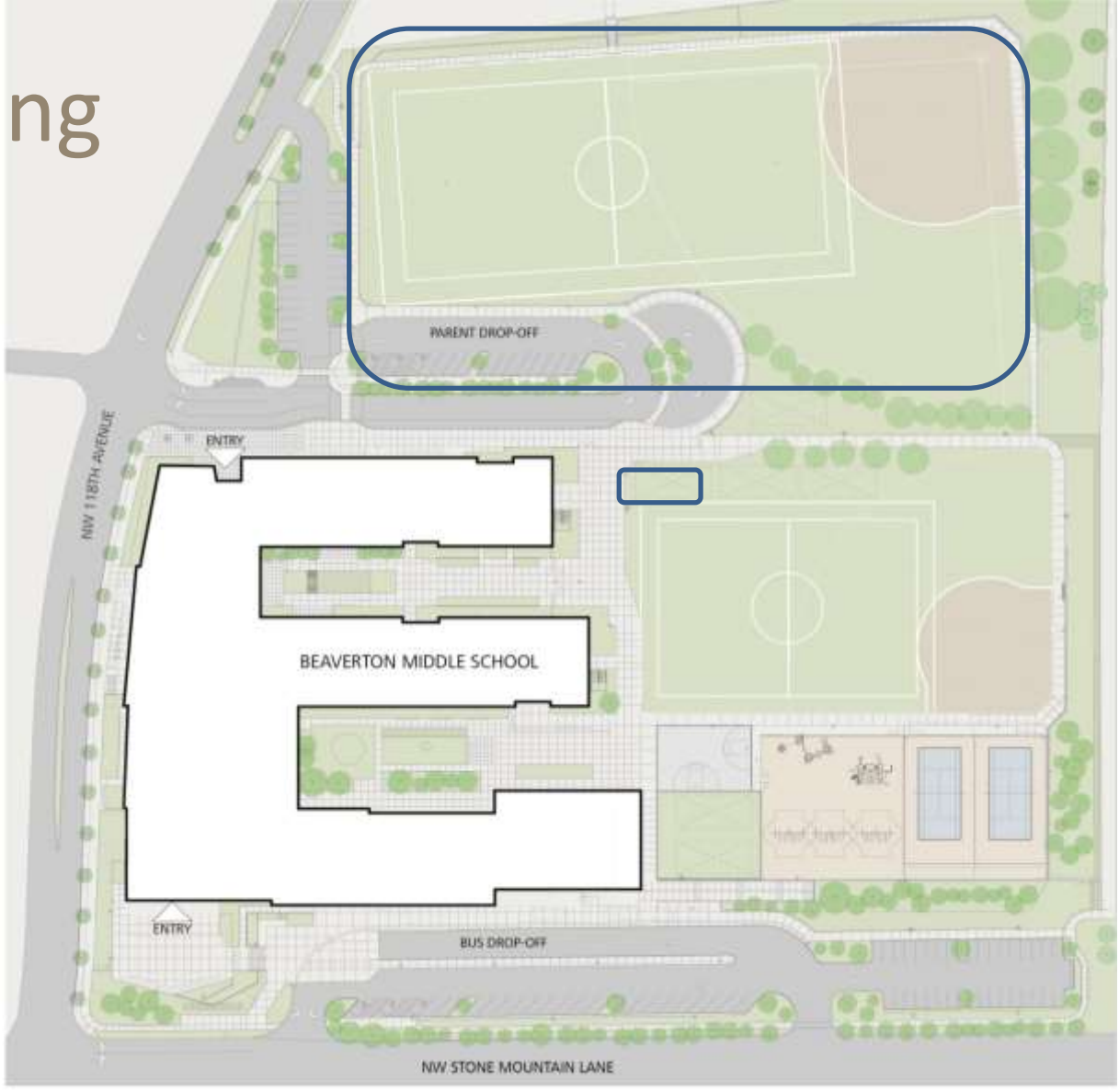
Beyond 30 days

Resume Classes

Distribution Center

Camp Area

Modular shower



0' 50' 100'

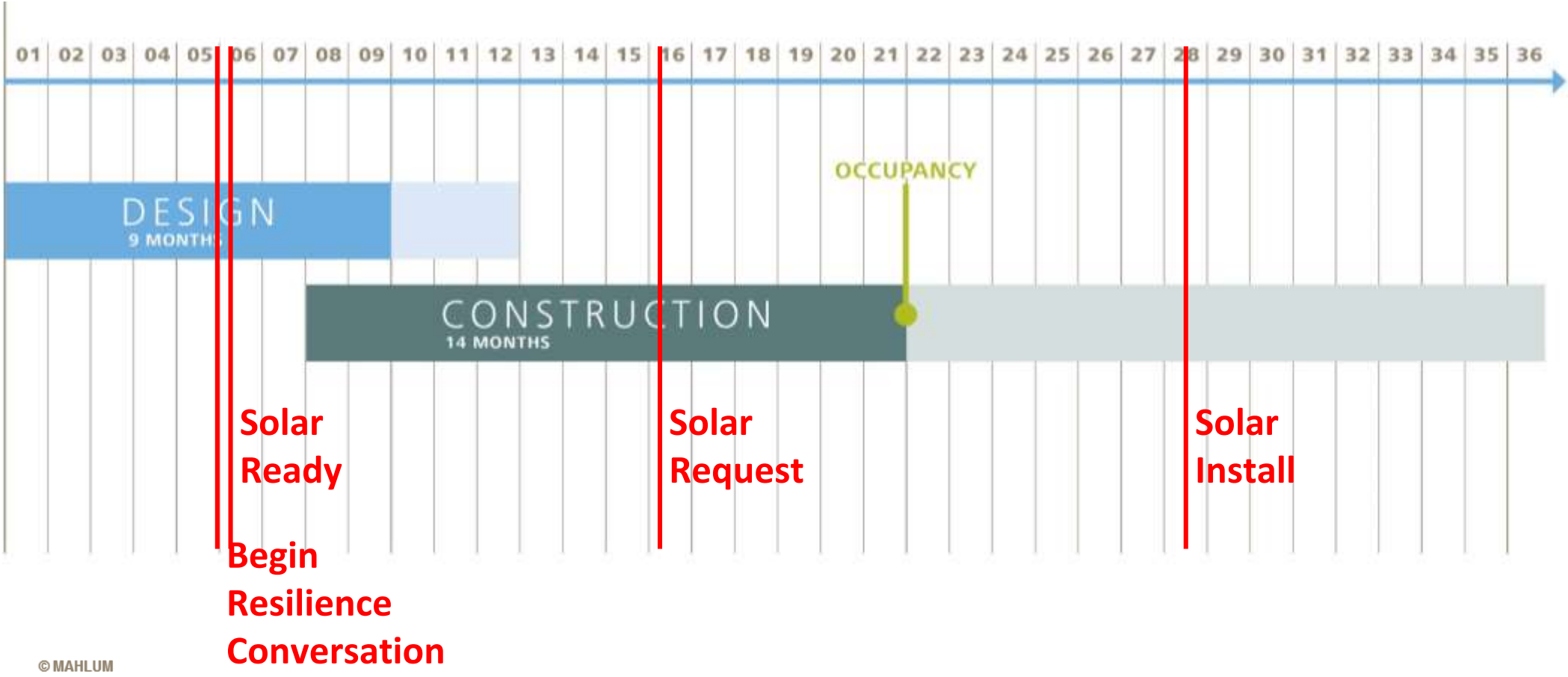
Solar Photovoltaics

Resilience

mahlum

Schedule

MONTHS



Resilient Features

LED LIGHTING

Cut wattage by **50%** throughout building.

SEISMIC RISK

Primary Structure designed to **IV**

WATER & WASTE

Strengthened
Add H2o valve

MECHANICAL

Gymnasiums and Commons HVAC on emergency generator with **4,000 gallon** capacity, 96 hr run time.
Limited power
Resilient electric hot H2o for kitchen

PV ARRAY

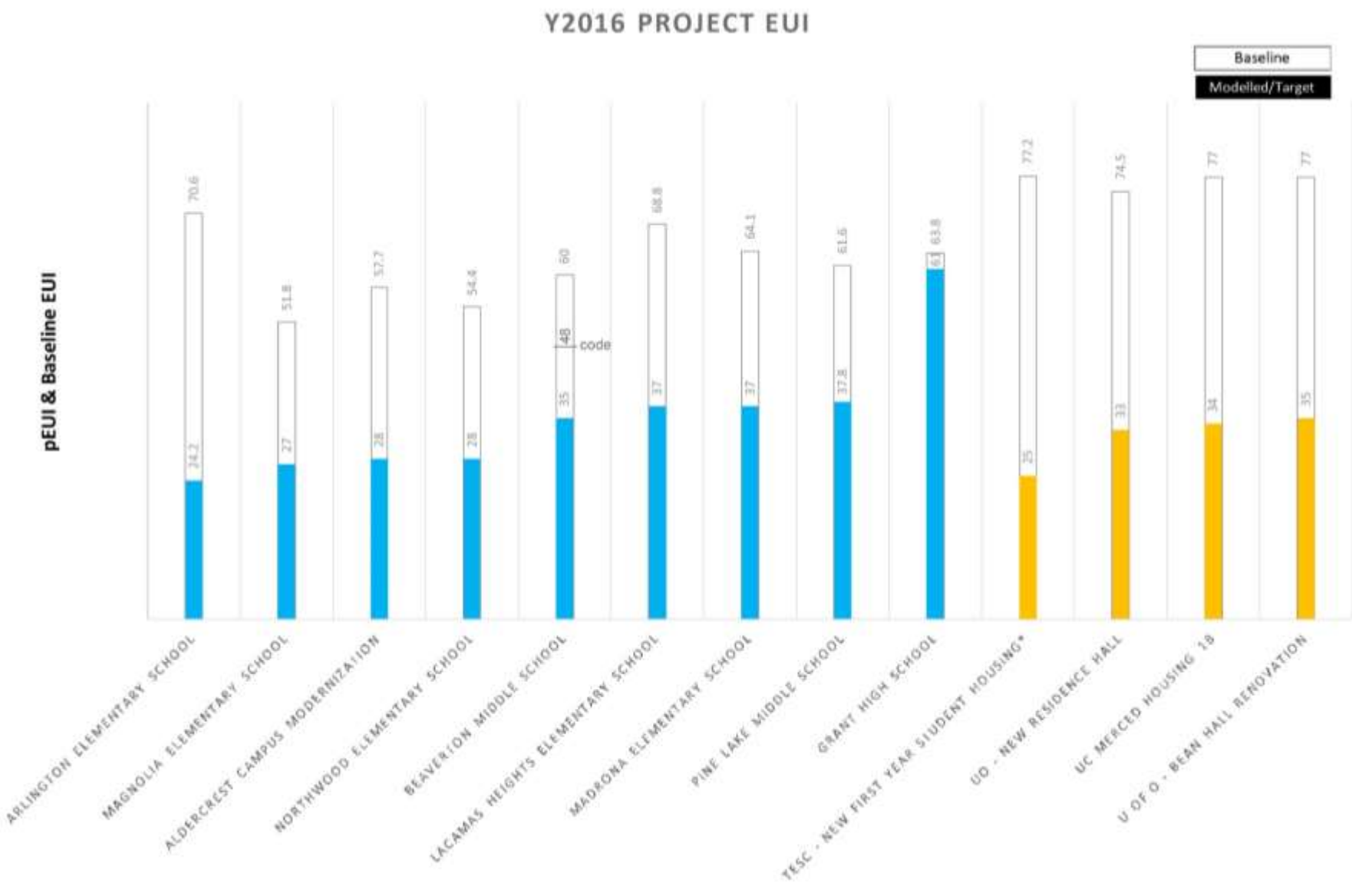
Total capacity is **128kW**.

Generates **129,616 kWh** per year.

COMMUNICATIONS

District radios
LAN, Security


Y2016 All Projects
WSSP
Modelled
Not Modelled
AIA 2030 target (70%)
pEUI reduction %
80
70
60
50
40
30
20
10
0
Arlington Elementary School
CLT Classrooms
Queen Anne Elementary School addition
Firgrove Elementary School
Aldercrest Campus Modernization
Northwood Elementary School
Magnolia Elementary School
Lacamas Heights Elementary School
Madrona Elementary School
Beaverton Middle School
Umpqua CC - Snyder Hall Design/Const.
Pine Lake Middle School
Grant High School
TESC - New First Year Student Housing
UC Merced Housing 1B
UO - New Residence Hall
U of O - Bean Hall Renovation
WWU - New Student Housing
UC Merced Housing 3D


Y2016 PROJECT EUI
Baseline
Modelled/Target
pEUI & Baseline EUI
70.6
34.2
51.8
27
57.7
28
54.4
28
60
48
35
code
68.8
37
64.1
37
61.6
37.8
63.8
61
77.2
25
74.5
33
77
34
77
35
ARLINGTON ELEMENTARY SCHOOL
MAGNOLIA ELEMENTARY SCHOOL
ALDERCREST CAMPUS MODERNIZATION
NORTHWOOD ELEMENTARY SCHOOL
BEAVERTON MIDDLE SCHOOL
LACAMAS HEIGHTS ELEMENTARY SCHOOL
MADRONA ELEMENTARY SCHOOL
PINE LAKE MIDDLE SCHOOL
GRANT HIGH SCHOOL
TESC - NEW FIRST YEAR STUDENT HOUSING*
UO - NEW RESIDENCE HALL
UC MERCED HOUSING 18
U OF O - BEAN HALL RENOVATION

Thank you!

Thank you!

Kurt Zenner AIA LEED AP
kzenner@mahlum.com

STRUCTURAL

KPFF Consulting Engineers

MEP

Interface Engineering

LANDSCAPE

Cameron McCarthy

CIVIL

Cardno

ACOUSTICS

Stantec

FOOD SERVICE

Halliday Associates

THEATER

PLA Designs

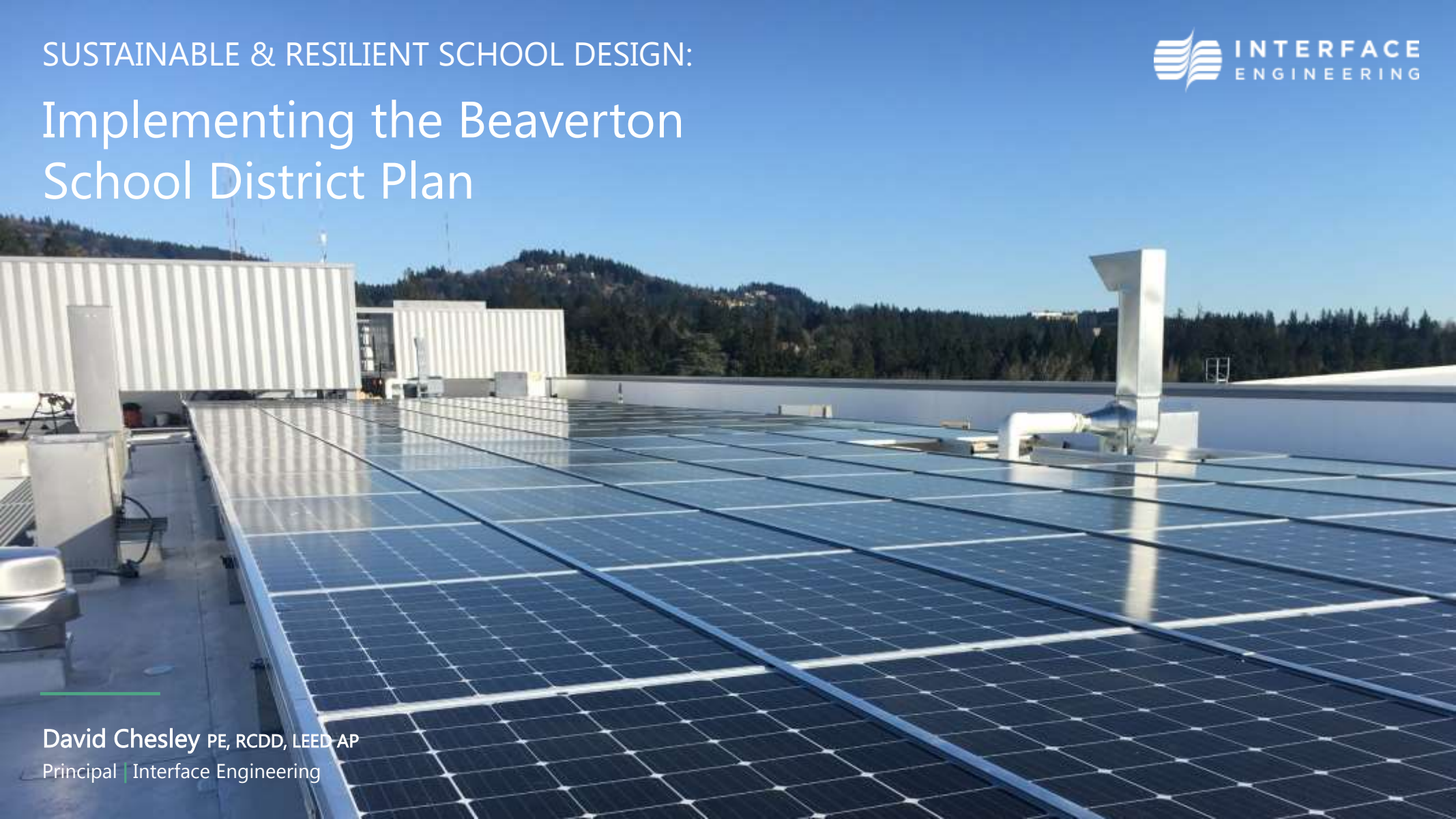
CMGC

Skanska

SUSTAINABLE & RESILIENT SCHOOL DESIGN:

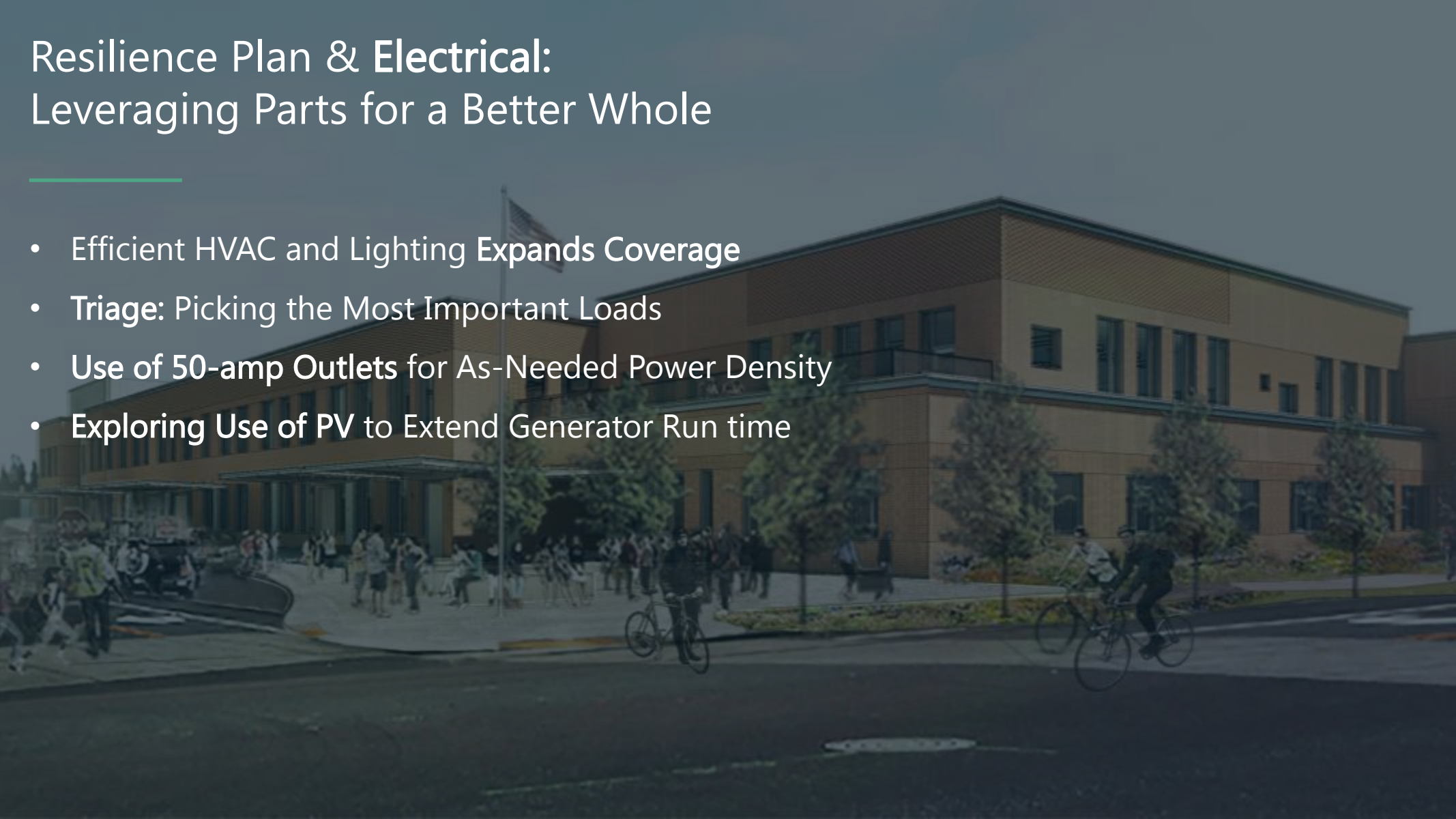
Implementing the Beaverton School District Plan

INTERFACE ENGINEERING



David Chesley PE, RCDD, LEED AP
Principal | Interface Engineering

Resilience Plan & **Electrical:** Leveraging Parts for a Better Whole



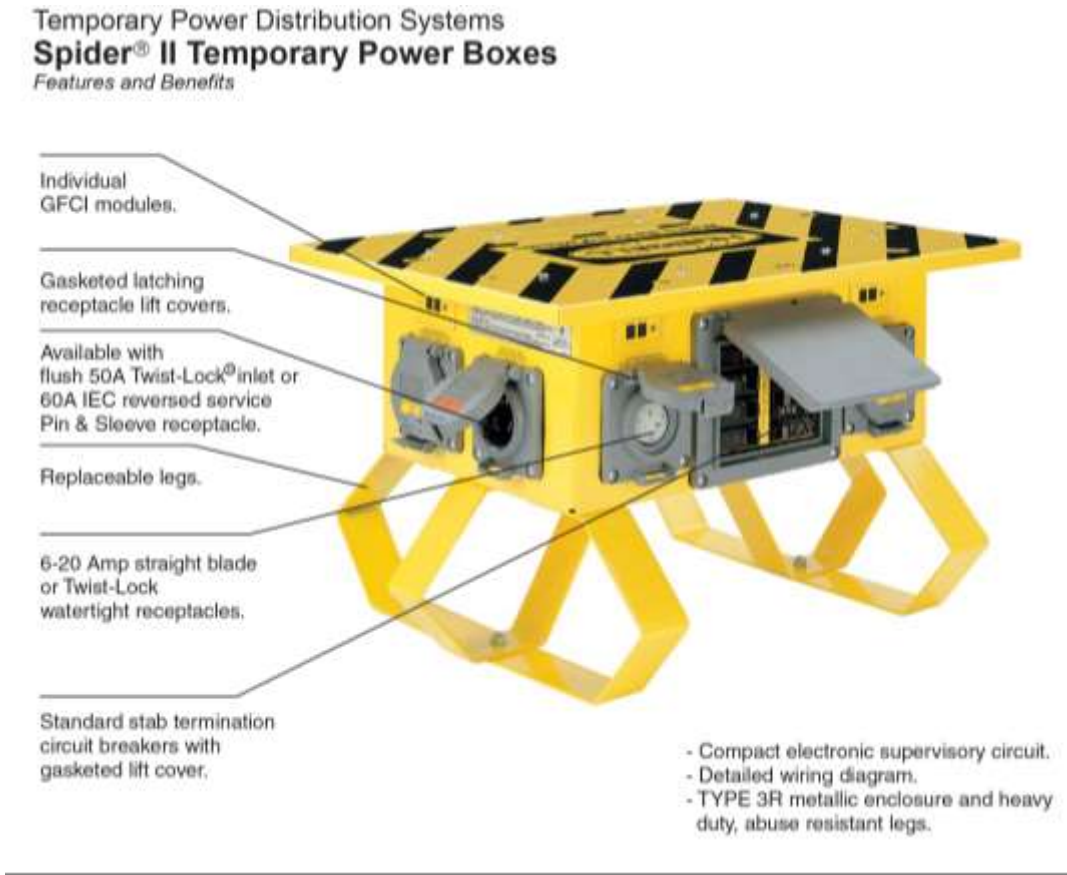
- Efficient HVAC and Lighting **Expands Coverage**
- **Triage:** Picking the Most Important Loads
- **Use of 50-amp Outlets** for As-Needed Power Density
- **Exploring Use of PV** to Extend Generator Run time

Impact of More Efficient Lighting on Generator

	Baseline (EUI 48)	Actual (EUI 38)	NOTES
Telecom/security	60kW	60kW	Includes door hardware
Water heater / boilers/ pumps	80kW	80kW	Central plant heating (if nat'l gas available) plus elec water heater for kitchen
Emergency ltg / fire alarm	20kW	10kW	Lighting code 1.01W/SF; actual: 0.43W/SF
Elevators	62kW	62kW	
Main Gym	91kW	60kW	Ventilation / LED ltg
Aux Gym	40kW	15kW	Ventilation / LED ltg
Lockers	56kW	31kW	Ventilation / LED ltg
Commons / Kitchen	157kW	74kW	Ventilation / LED ltg
Main Office	68kW	36kW	Ventilation / LED ltg
Site Lighting	20kW	4kW	LED lighting
TOTAL	654kW	432kW	

Heavy duty outlets for power density when needed

- Temp power when needed for food warmers, med equipment, etc.
- Two flush boxes located inside commons area, both on standby power.
- Two flush boxes located just outside commons area, both on standby power.
- 208-volt, 3-phase, 50-amp at each outlet equals 14.4kW at each location.



Use of load bank
to extend generator life

- NFPA 110 (Standards for Emergency & Standby Generators) and monthly testing
- NFPA 110, 8.4.2 recommends generators testing under load >=30% nameplate KW
- Avoid fuel and soot build-up (wet-stacking); burn fuel more efficiently

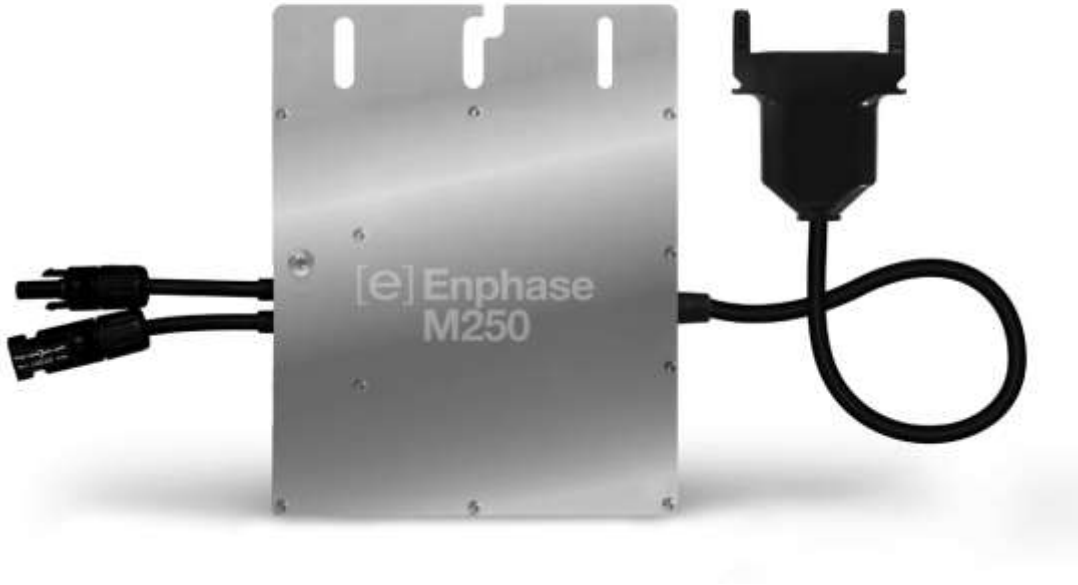
LSH 50 KW Permanent Resistive Avtron Load Bank.

Exploring PV for Extending the Fuel Supply

PV Inverter Choices for Higher Efficiency

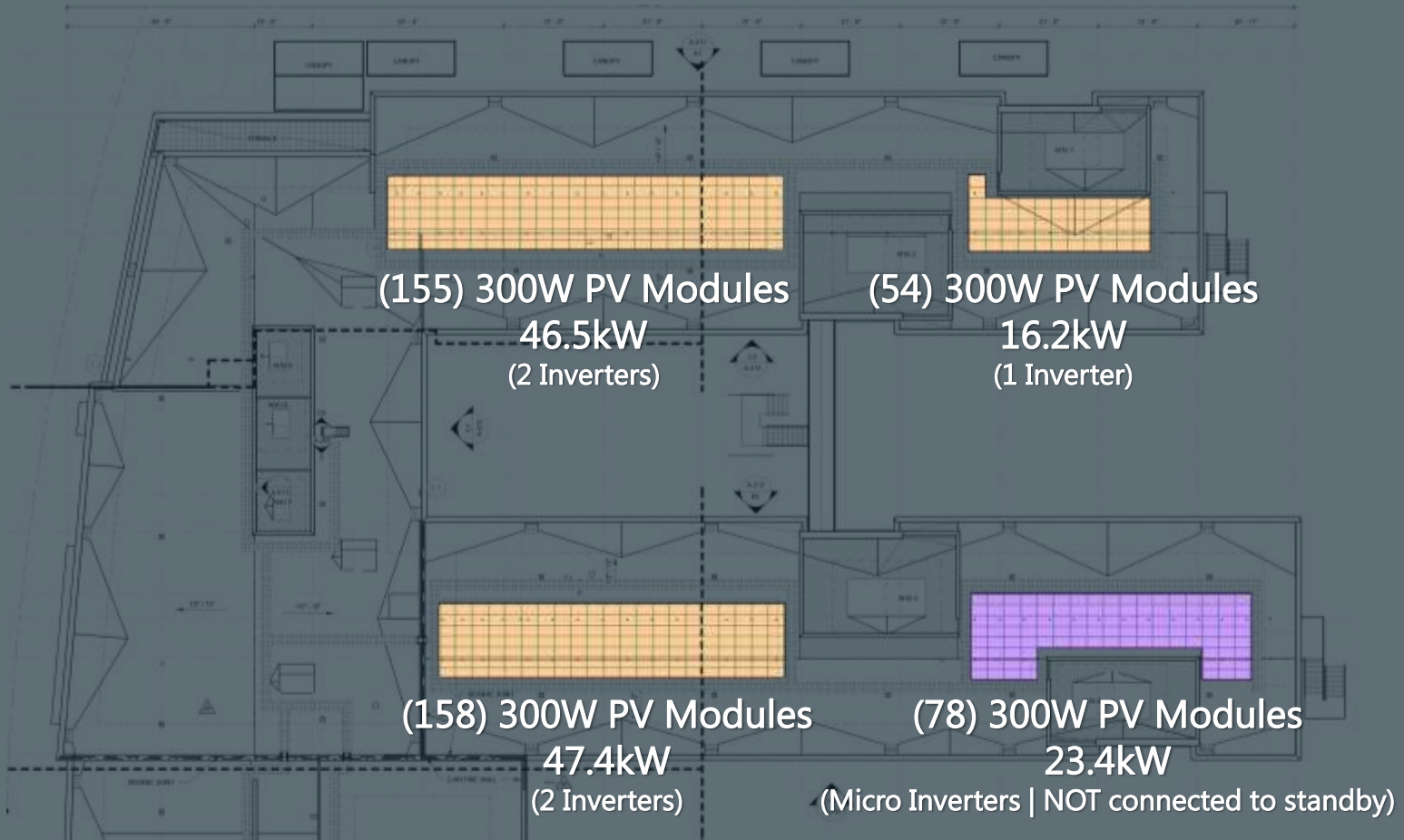
- Grid interactive for synchronizing voltage and frequency
- Micro-inverters help combat shading (the flashlight battery analogy)

SMA Tripower Inverter (grid-interactive)



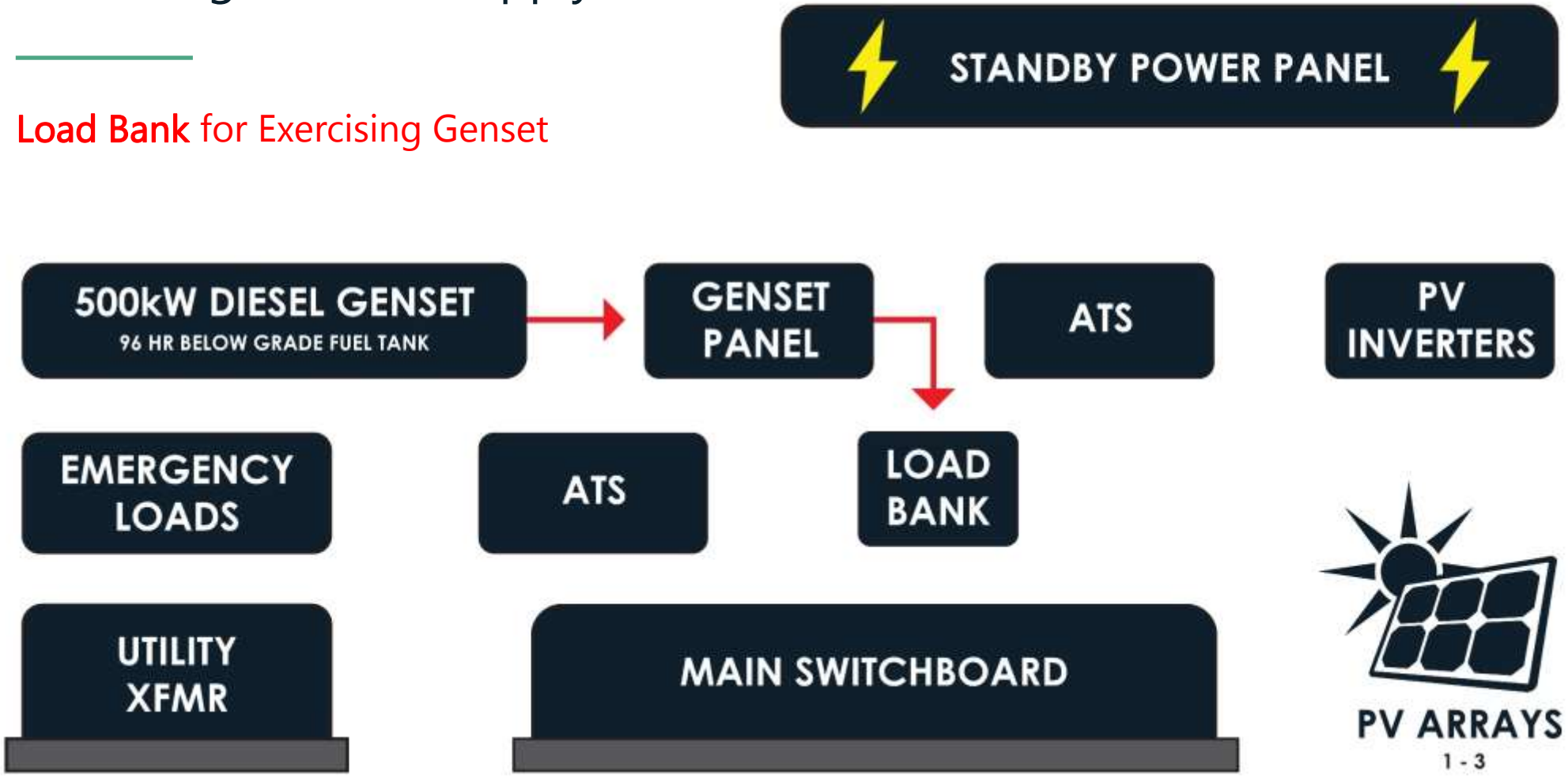
Enphase 250-watt (micro-interter)

Exploring PV for
Extending the Fuel Supply



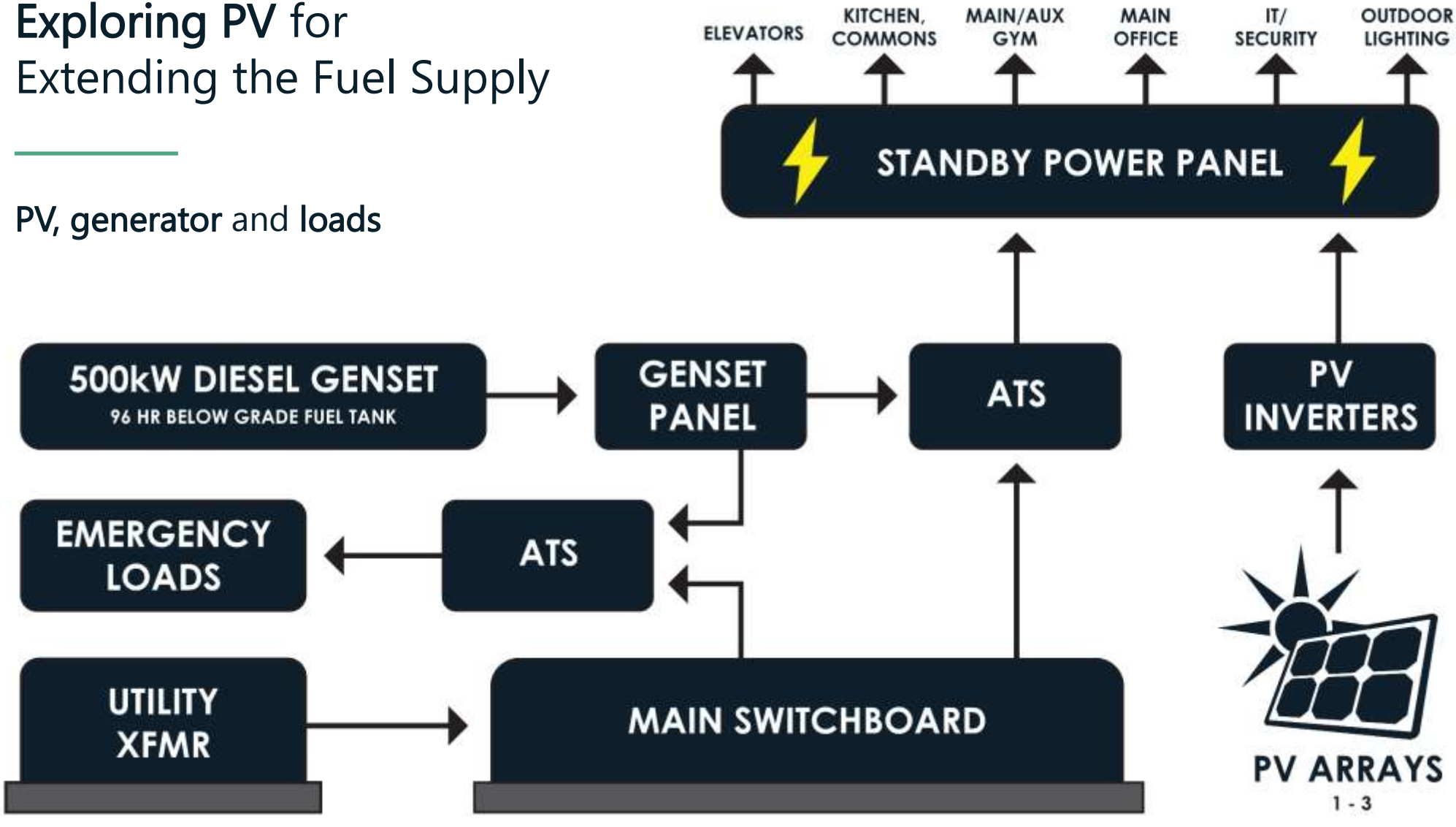
Exploring PV for Extending the Fuel Supply

Load Bank for Exercising Genset



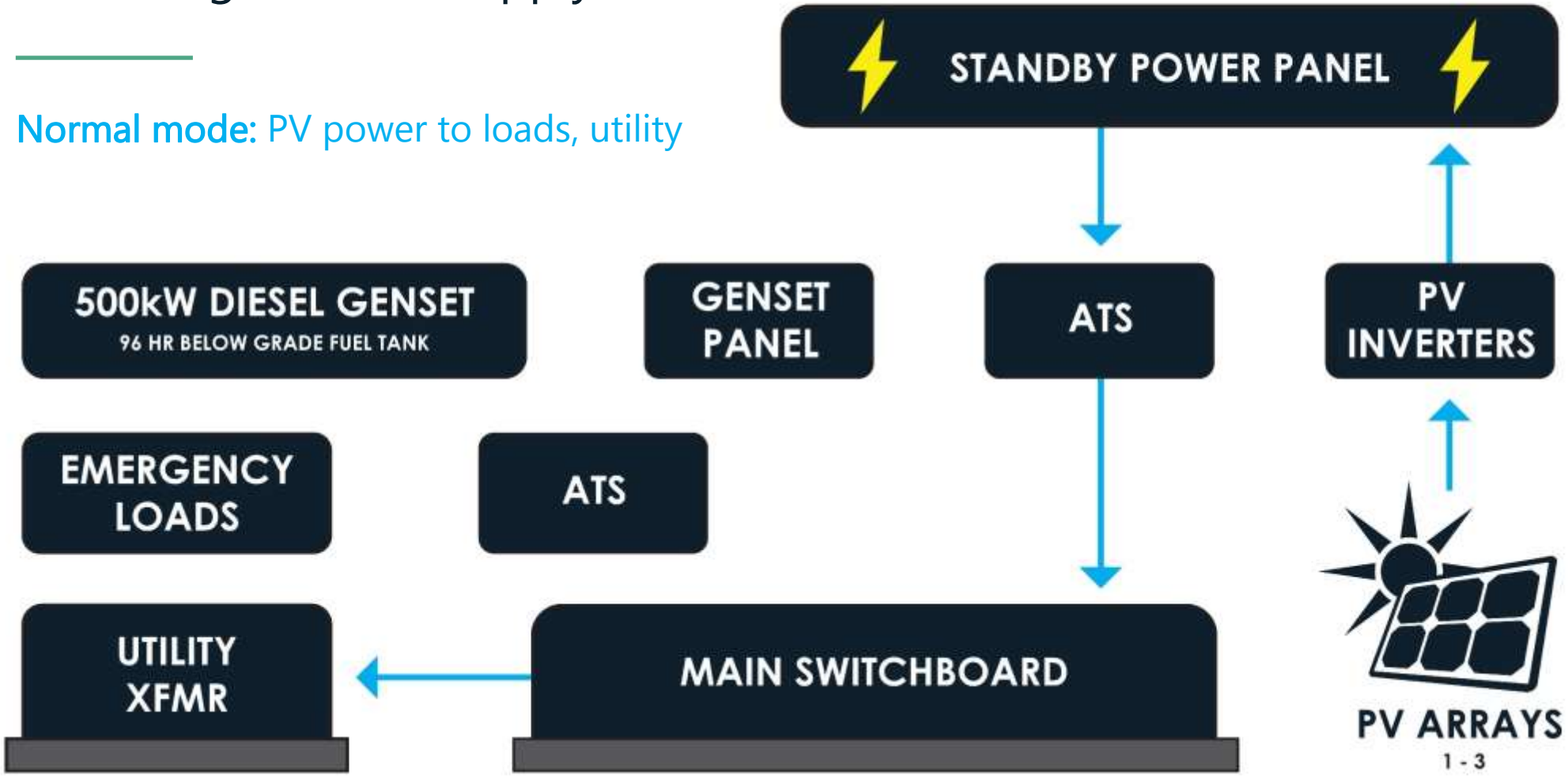
Exploring PV for Extending the Fuel Supply

PV, generator and **loads**



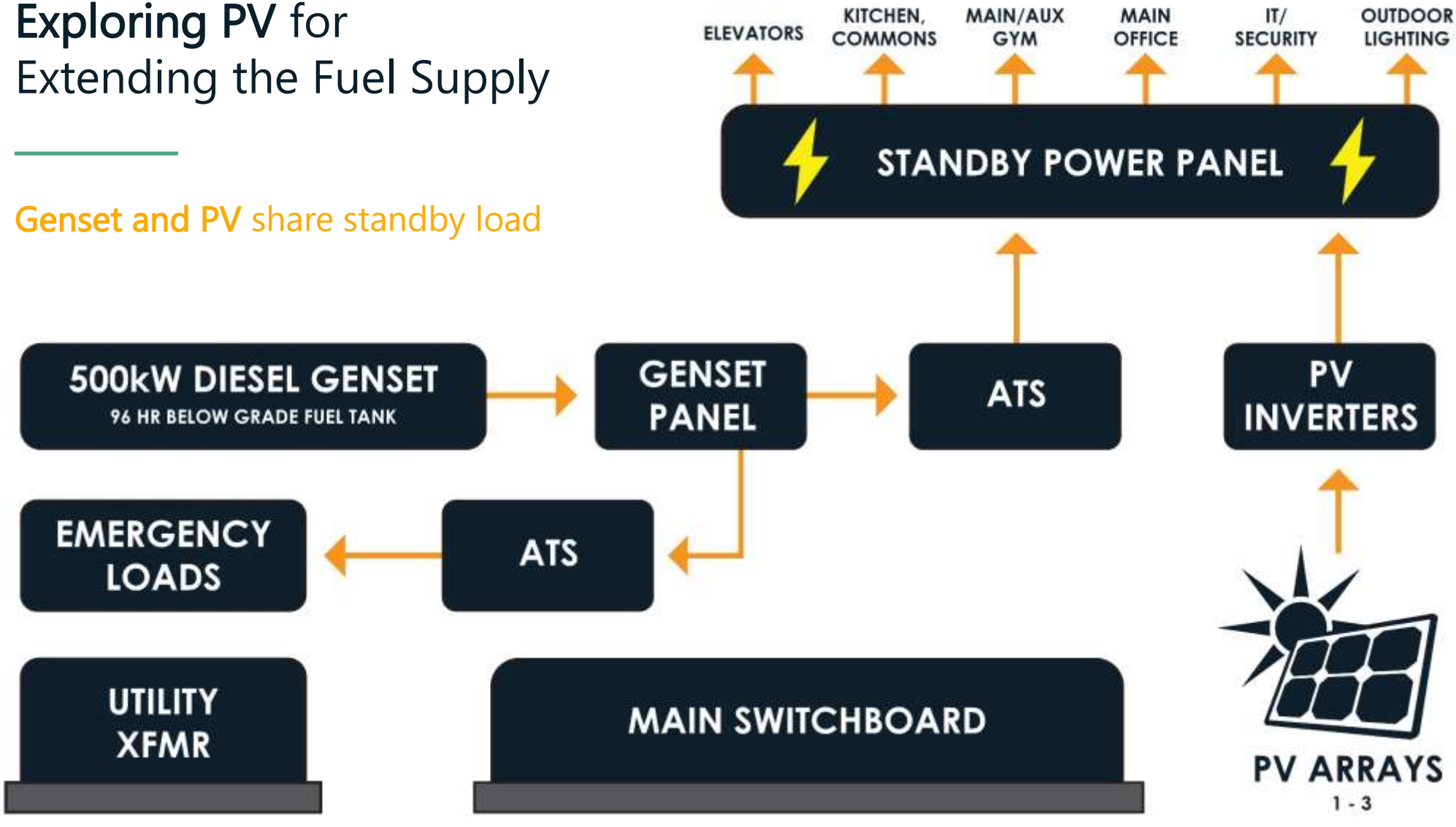
Exploring PV for Extending the Fuel Supply

Normal mode: PV power to loads, utility



Exploring PV for Extending the Fuel Supply

Genset and PV share standby load



Work in Progress:
Lessons Learned on PV/Generator Design

1. Protective relays: **reverse power flow** on generator
2. Engaging utility and code officials **early in design**
3. Approved sources of power under **NEC Article 700 and 702**
4. Generators and the **35% rule** (adding future loads)