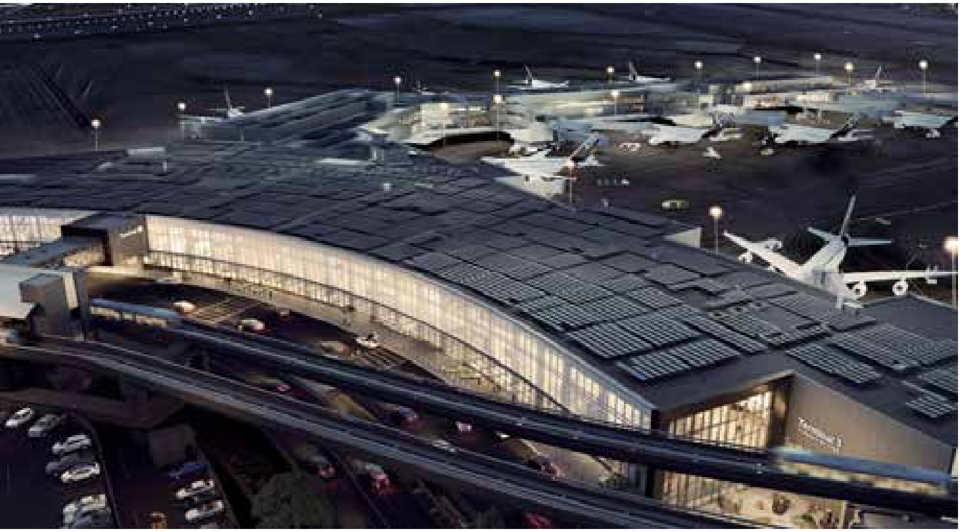
Integrating Radiant and Displacement Systems at SFO to Meet Strategic Sustainability Goals

Symposium on Optimizing Radiant Systems

Wednesday, October 23rd, 2019

Agenda

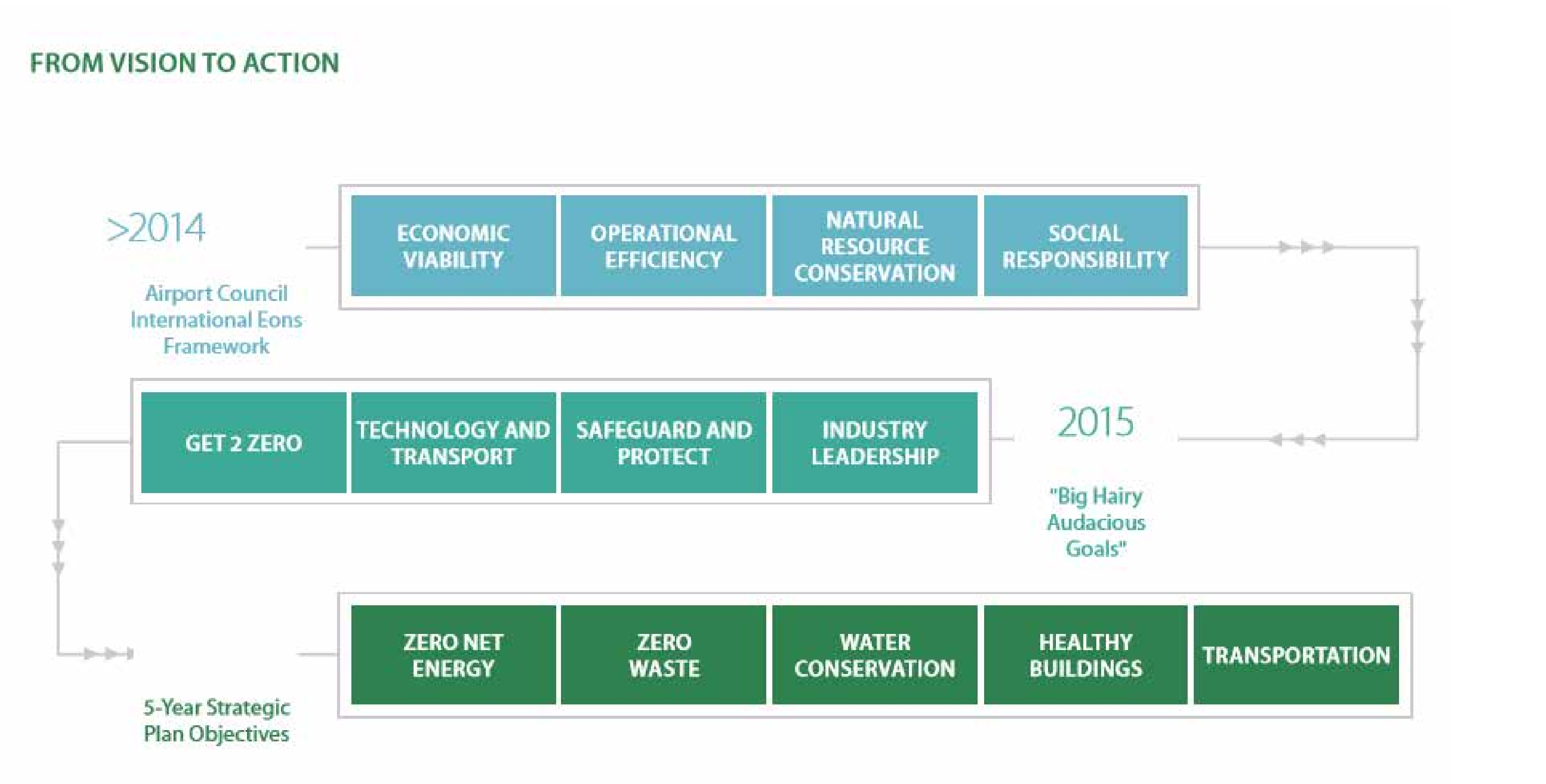
1. Sustainability as a Guiding Principle
2. Harvey Milk Terminal 1 Project Description
    a. Energy Strategies
3. Radiant Heating / Cooling + Displacement Ventilation
4. Commissioning Activation Simulation
    a. Operational Readiness and Transition (ORAT)
5. Cost and Benefits
    a. Triple Bottom Line Cost Benefit Analysis



Sustainability as a Guiding Principle

1

SFO Strategic Sustainability Goals



Harvey Milk Terminal 1 Sustainability Goals

Harvey Milk Terminal1 Project Description

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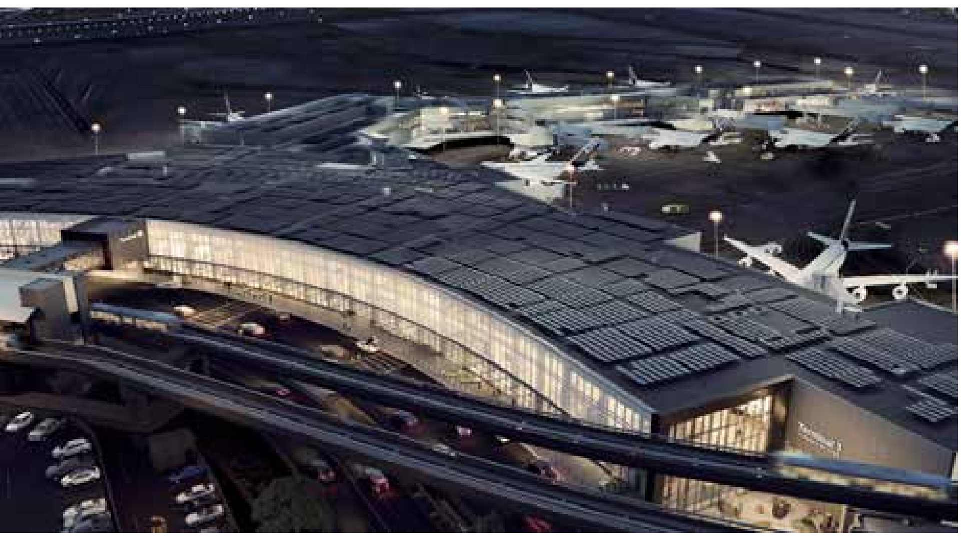


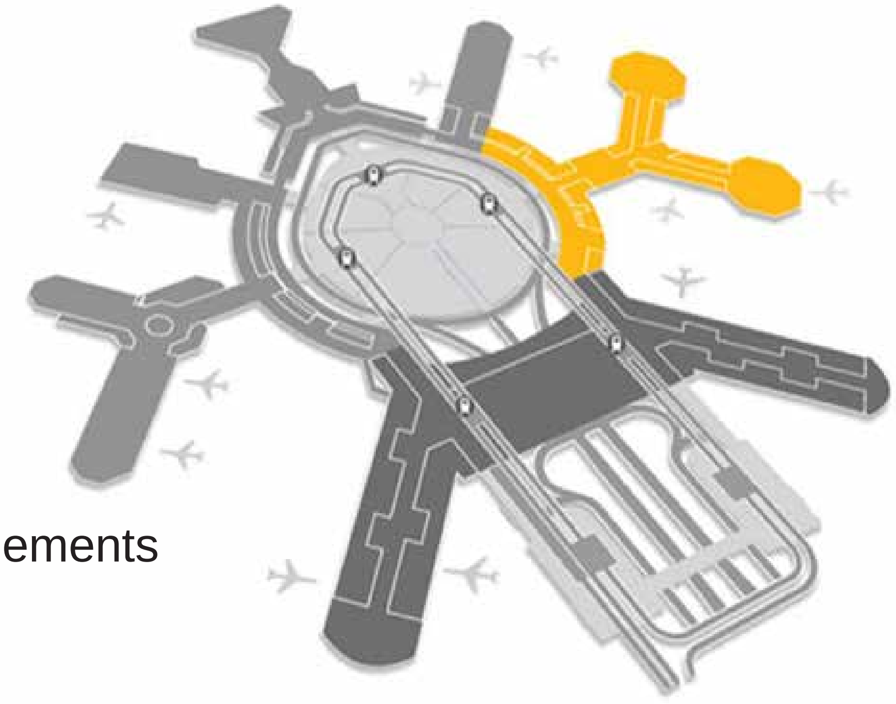
Harvey Milk Terminal 1

- **Terminal 1 Center**
  - Check-In
  - Security Checkpoints
  - ICS Baggage Handling System
  - Construction: 2016 – 2023
  - Project Budget: $1.4 B
  - Design-Builder
    - Hensel Phelps Construction Company
    - Gensler
    - Meyers+
    - Critchfield Mechanical, Inc.

Harvey Milk Terminal 1

- **Boarding Area B**
  - 28 Gates (Includes 7 International Swing Gates)
  - Multiple Tenant &
    Airline Lounge Spaces
  - Aircraft Apron
  - Construction: 2016 – 2021
  - Project Budget: $865 M
  - Design-Builder
    - Austin Webcor JV
    - HKS + Woods Bagot
    - ARUP
    - Southland Industries

Previous Terminal 1



§ Initiated operations in 1961

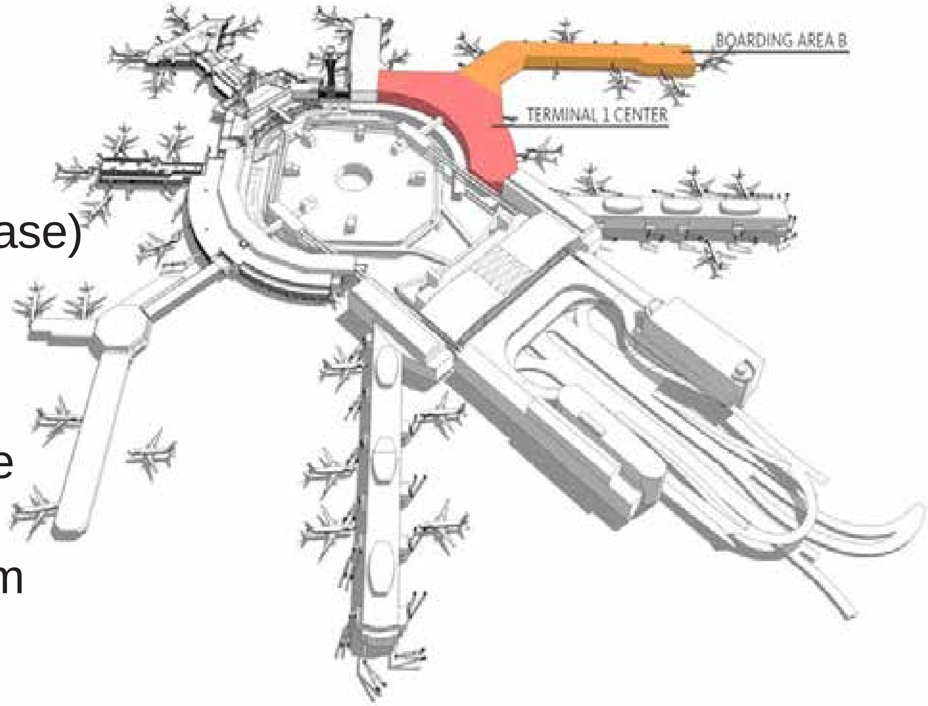
§ Renovated mid-1980s

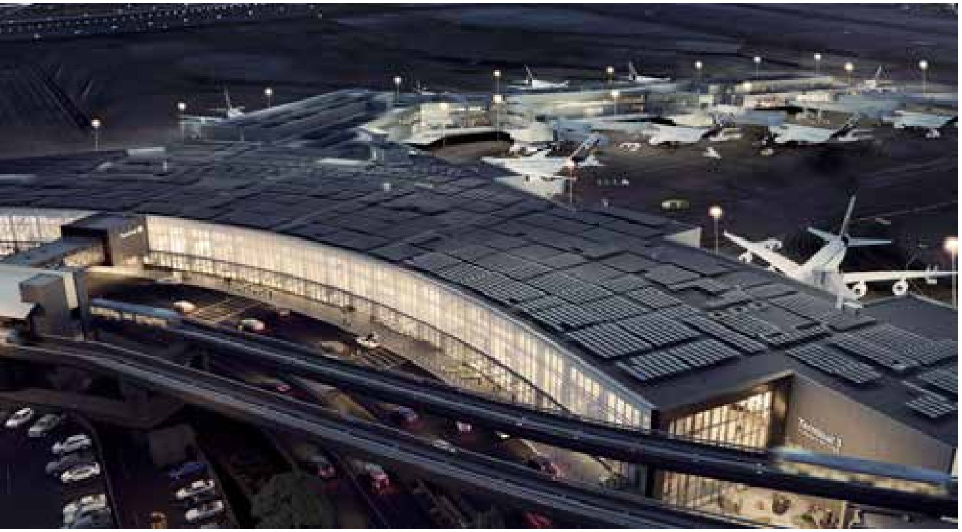
§ Operated at 4.7 million annual enplanements

Harvey Milk Terminal 1

§ Designed for:

- Ø 8.8 Million Annual Enplanements
- Ø 17 Million Passengers (70% Increase)
- Ø Operational Flexibility
- Ø Exceptional passenger Experience
- Ø Celebration of Bay Area Naturalism
- Ø SFO Net Zero Goals





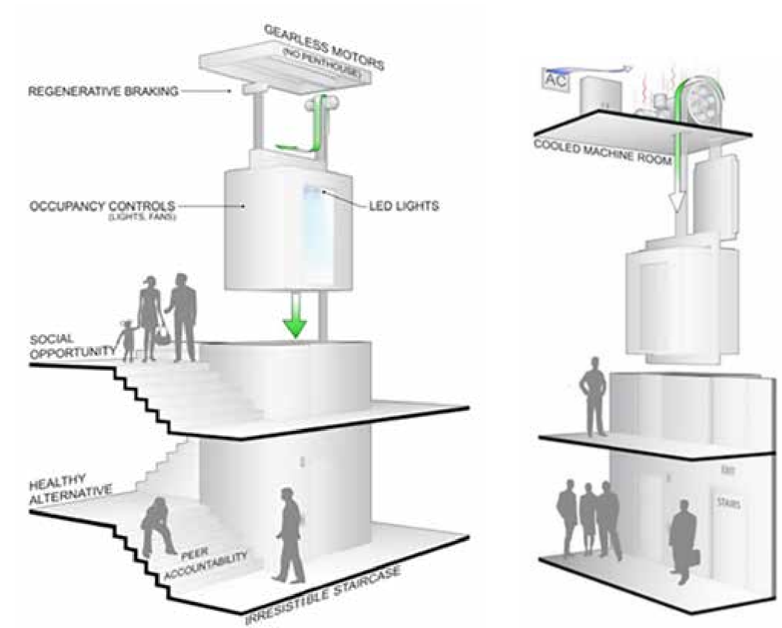
Energy Strategies

2a

2a. Horizontal & Vertical Transportation: ~1EUI

- **Escalators and Moving Walks** – "Go Slow" Mode
- **Elevators** – Energy Recovery

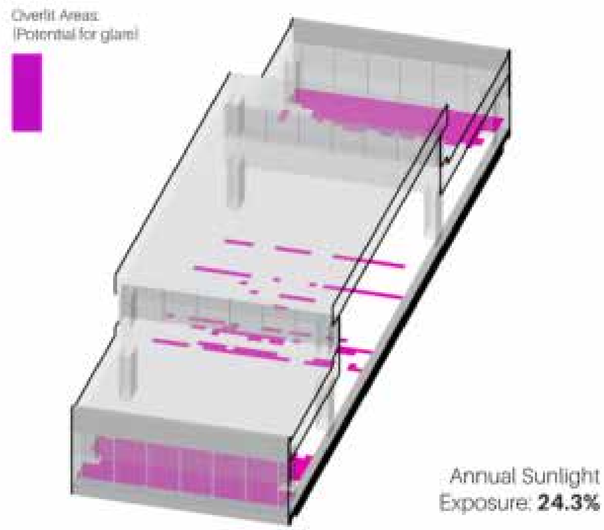
Check-In Lobby

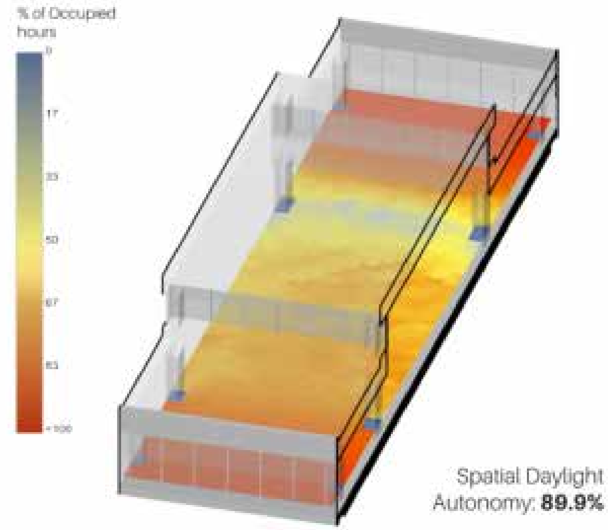


Regenerative Elevator		
	BAB	**T1C**
BENEFIT	Reduced Energy	
EUI REDUCTION	~0.5	~0.3-0.5

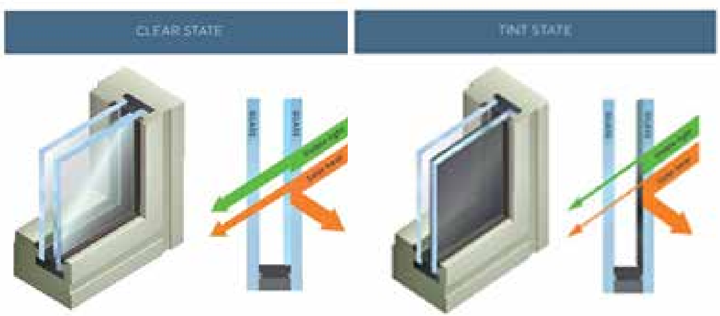
2a. Daylight + Glare Strategies: <1 EUI

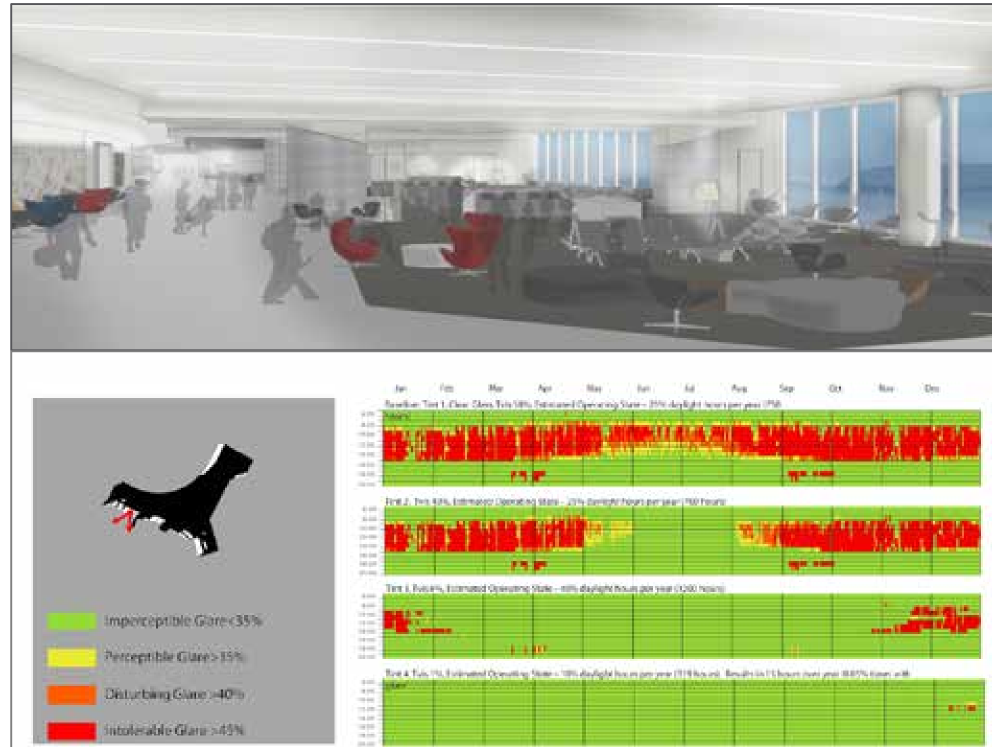
**Note: All perspective images are depicted at June 21, 6:00pm PST influencing the appearance of dynamic shading options.*





2a. Dynamic Glazing





T1 Glare Analysis | SW Facade

Dynamic Glazing (BAB only)	
BENEFIT	Glare Control
EUI REDUCTION	0

Dynamic Glazing (T1C only)	
BENEFIT	Reduced Energy, Glare Control
EUI REDUCTION	~1-2

2a. Ground Service Equipment (GSE)

- Transition to Electric GSE
- EV Charging Stations
- Metering Energy Consumption

Process Loads		
	BAB	T1C
BENEFIT	Manage energy consumption	
EUI REDUCTION	0	0

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2a. Aircraft Ground Efficiencies

400Hz Power & Pre-Conditioned Air to Aircraft

- Reduced Energy Use
- Reduced Cost
- Improved Air Quality
- Improved Passenger Comfort

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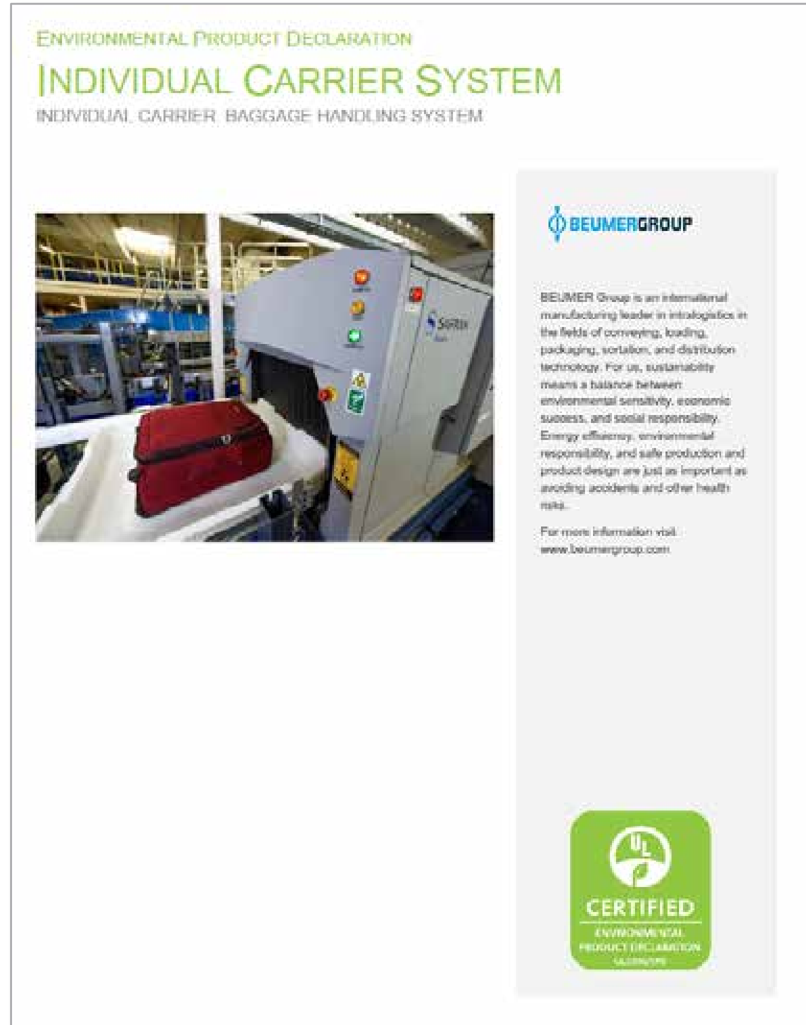
2a. Baggage Handling System (BHS): ~6 - 10 EUI

- Energy Reduction = ~ 50%
- BHS EPD
- Totes HPD
- Reduced material use
- ICS represents ~6% Project Carbon Footprint



ENVIRONMENTAL PRODUCT DECLARATION

INDIVIDUAL CARRIER SYSTEM

INDIVIDUAL CARRIER BAGGAGE HANDLING SYSTEM

BEUMER GROUP

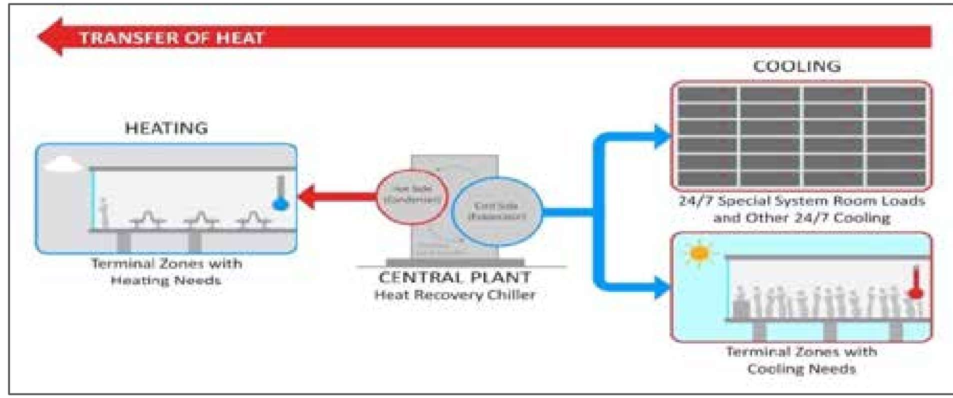
BEUMER Group is an international manufacturing leader in intralogistics in the fields of conveying, loading, packaging, sortation, and distribution technology. For us, sustainability means a balance between environmental sensitivity, economic success, and social responsibility. Energy efficiency, environmental responsibility, and safe production and product design are just as important as avoiding accidents and other health risks.

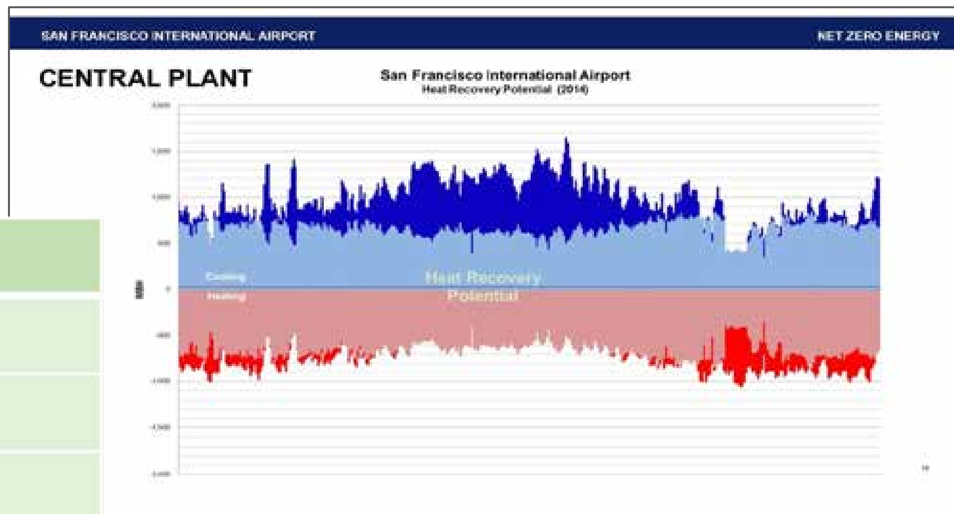
For more information visit www.beumergroup.com

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

2a. Heat Recovery Ready

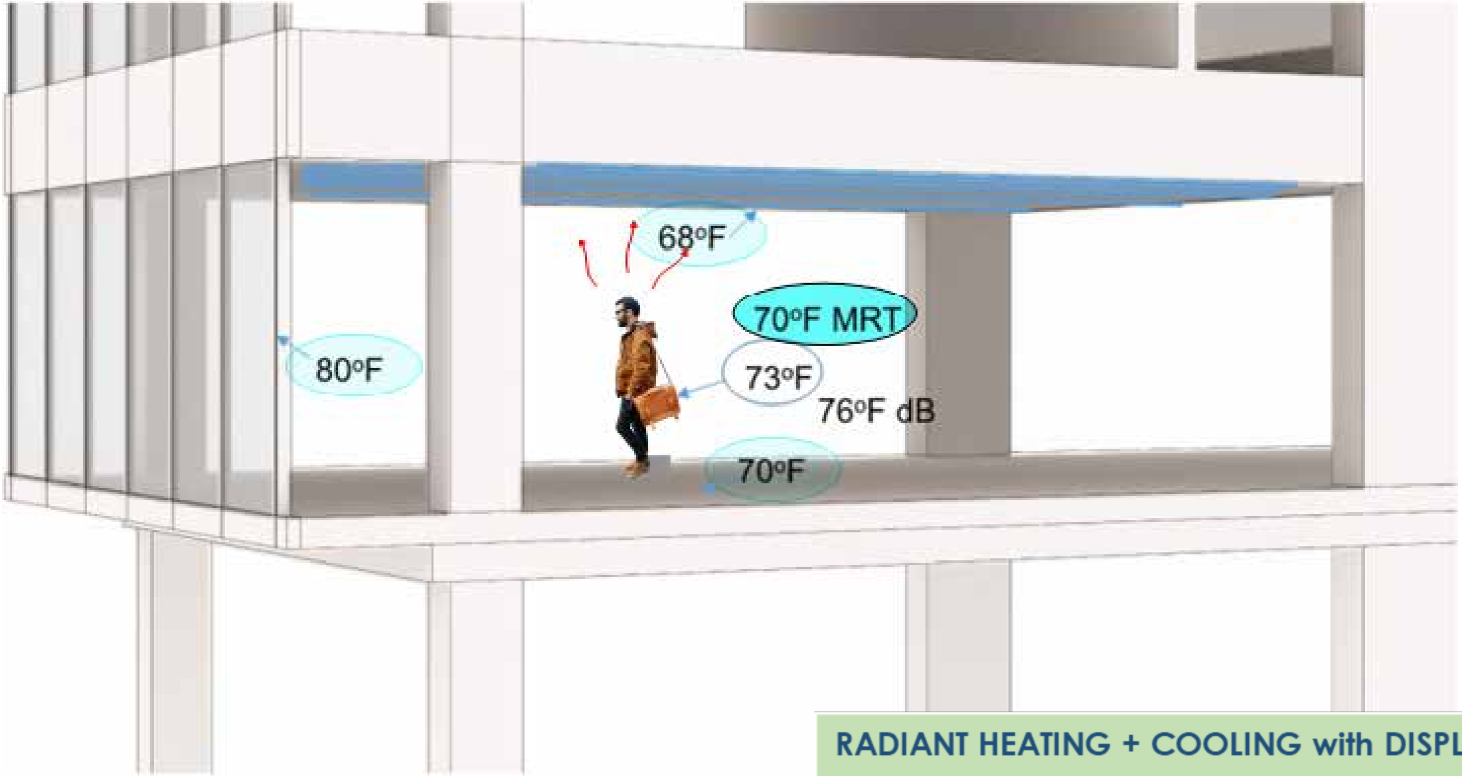
- Larger pipe size
- Additional pumps
- Temperature adjustments





Heat Recovery Ready		
	BAB	**T1C**
BENEFIT	Reduced Energy	
EUI REDUCTION*	~16	~11

2a. Radiant Heating & Cooling

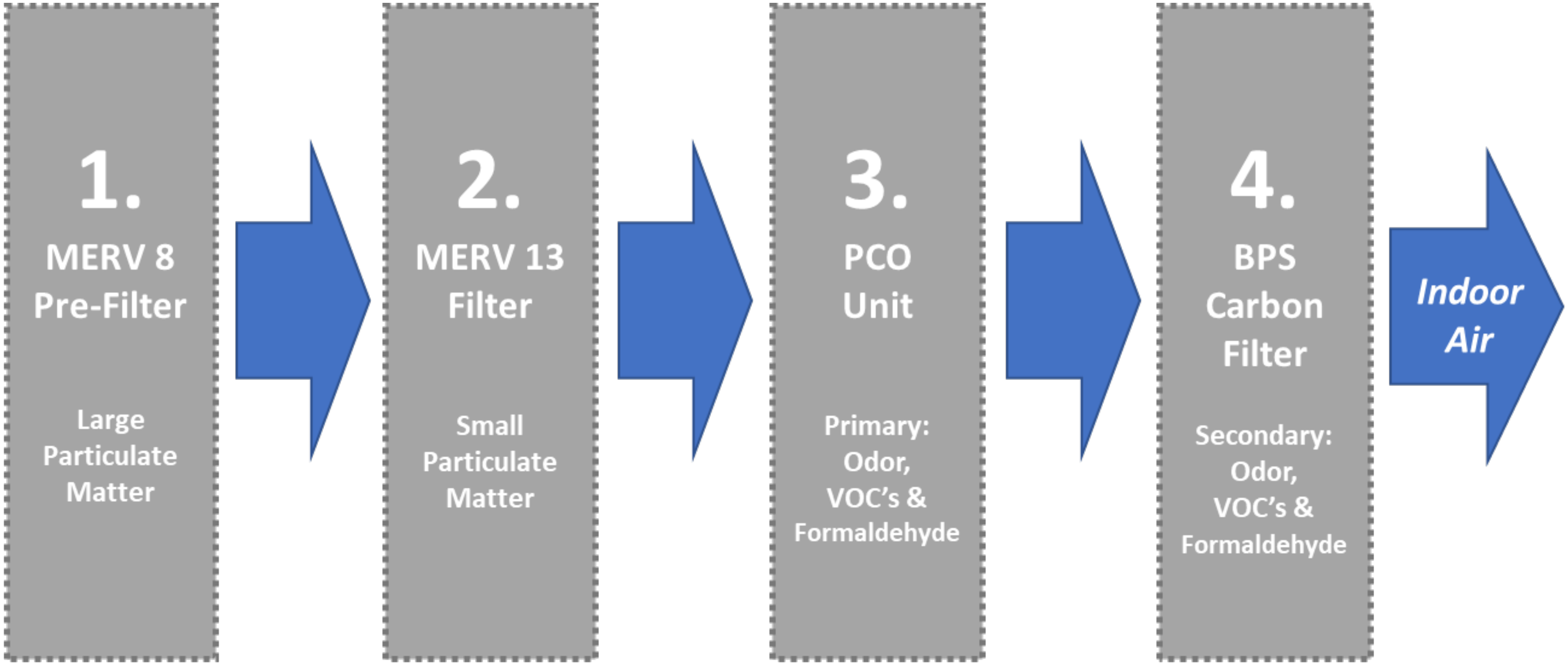


RADIANT HEATING + COOLING with DISPLACEMENT AIR		
	BAB	**T1C**
BENEFIT	Reduced Energy + Carbon; Comfort	
EUI REDUCTION*	~41	~0.5-1.0

2a. Photovoltaic Panel System: ~19 EUI

PV Panels (BAB only)	
BENEFIT	Reduced Energy
EUI REDUCTION	~11
PV SYSTEM SIZE	1,043 kW
EST. ANNUAL OUTPUT	1,425,300 kWh/yr
ELECTRICITY COST ($/kwh)	$0.131/kWh
ANNUAL ENERGY SAVINGS	$186,714.30

2a. Advanced Filtration



__Notes:__
PCO = Ultra-Violet Photocatalytic Oxidation
BPS = Bonded Particulate Structure
VOC = Volatile Organic Compound

- Naphthalene: 0.053 µg/m3
- Formaldehyde: 9 µg/m3

Advanced Filtration		
	BAB	**T1C**
BENEFIT	Improved Indoor Air Quality	
EUI **IMPACT**	~0.25	

2a. Energy Metering

Electricity

- T1C and BAB separately
- Variable Frequency Drives for Mechanical
- Lighting 1x per panel
- Distribution 1x per panel (BHS, elevators, 120V circuits, etc.)
- Apron Controls – PBB, PC Air, and GSE

Water (potable and recycled)

- T1C and BAB separately
- Tenants

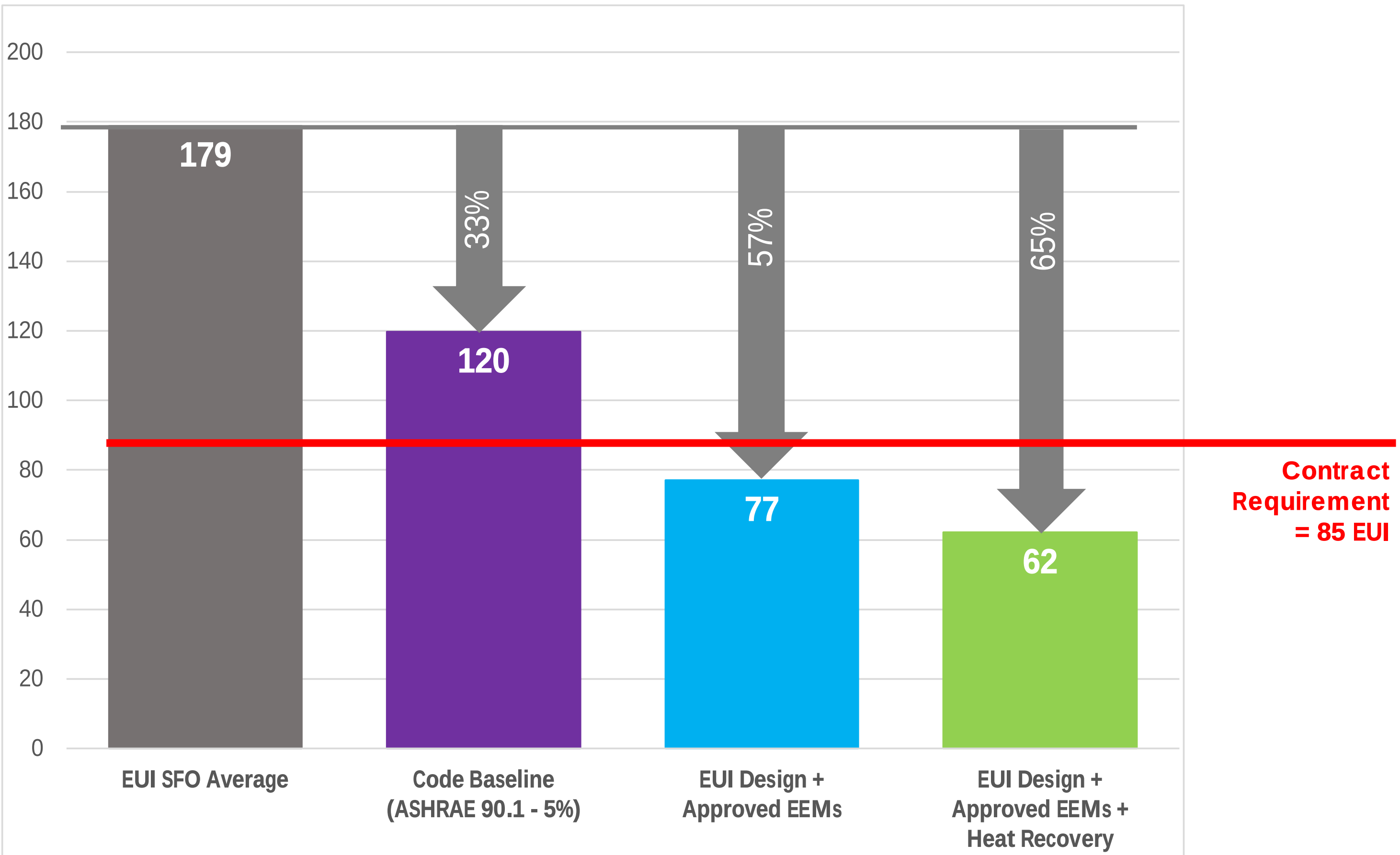
Chilled and hot water

- T1C and BAB separately
- BTU Meters (Tenants)

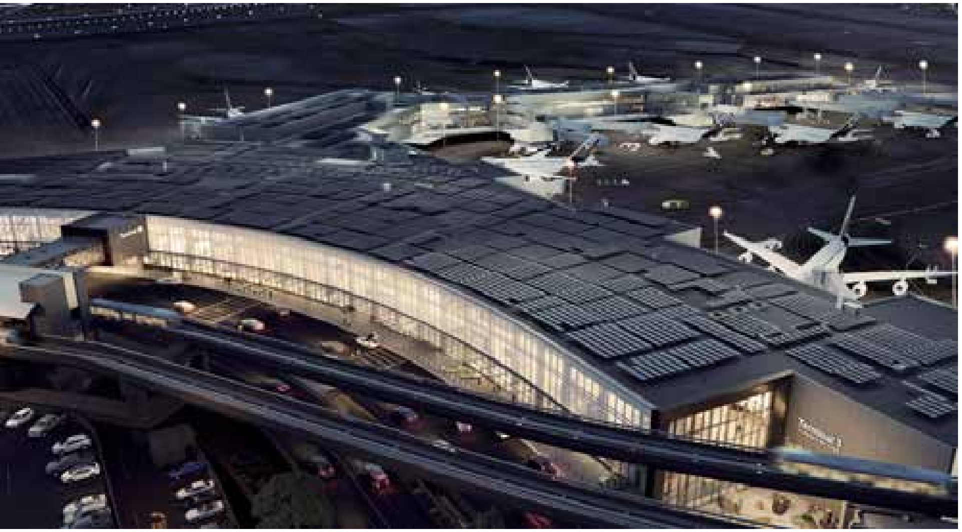
Gas

- Food & Beverage Tenants
- Airline Lounges

Energy Use Intensity (EUI) Summary



- Approved EEMs: Radiant Heating & Cooling, Photovoltaics, Advanced Filtration, Vertical Transportation & Dynamic Glazing
- All EUI values include process loads



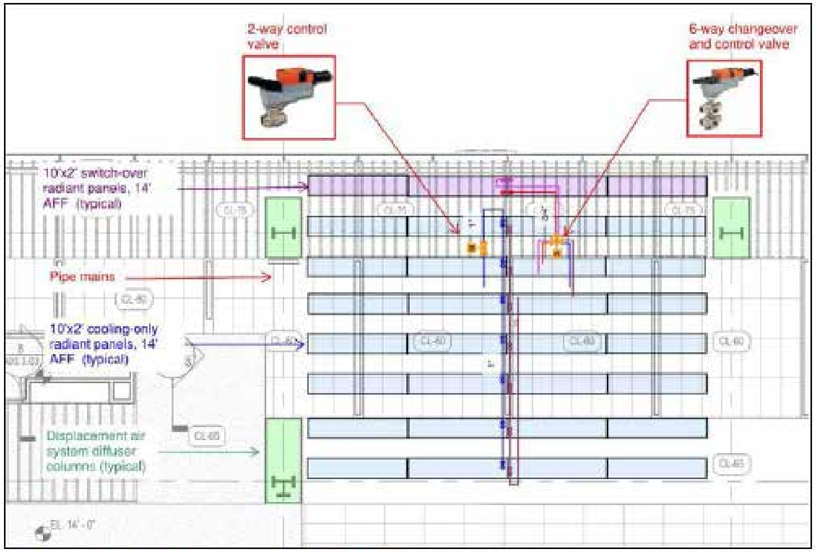
Radiant Heating / Cooling + Displacement Ventilation

3

3. Radiant Heating & Cooling

Experiential & Operational Considerations	
Passenger & Employee Experience +++	Better thermal comfort, rapid response time, additional noise absorption for acoustic comfort, minimal visual profile
Future Flexibility ++	Panels are easily reconfigured
Innovation Acceleration ++	SFO T3, BAE and Dublin Airport are the only airports to use radiant ceilings
Operational Factors ++	Tilt-down access for maintenance, push-fit connectors
Schedule Implications + \ -	Needs early coordination with other mechanical components, glazing selection, and interiors
Other Decision Factors +++	Minimizes displacement ventilation system size

Environmental & Financial Performance	
EUI Reduction (kbtu/sf)	-12.7
Energy Savings ($/yr)	$112,000
Simple Payback (yrs)	62
EUI Unit Cost ($/EUI)	$551,000
Carbon Reduction (mTons/yr)	503
Avoided Cost of Carbon ($/yr)	$25,900



Draft ceiling panel layout for typical hold room

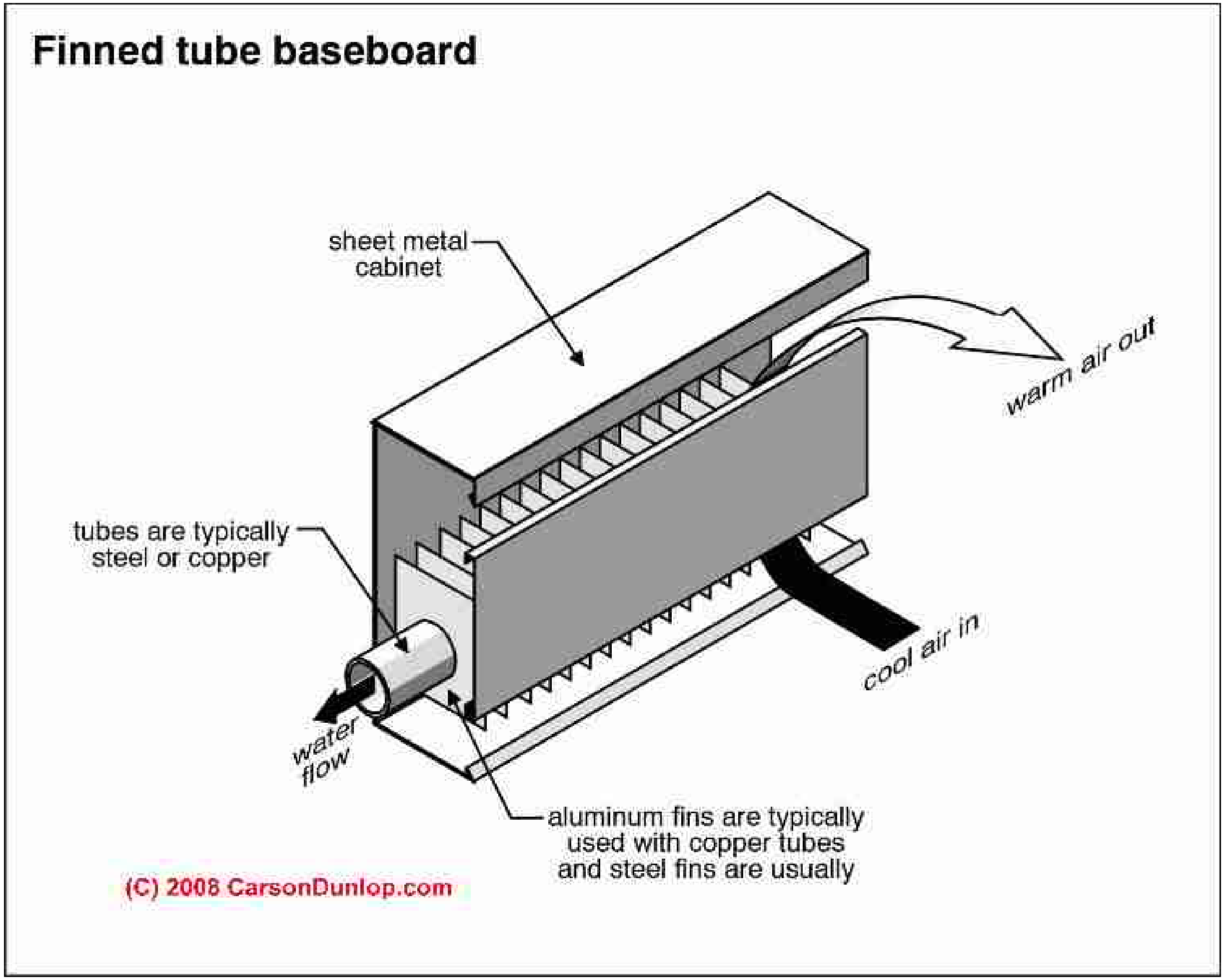
3. Radiant Heating and Cooling

Check-In Lobby

ARRIVALS

DEPARTURE

3. Radiant Heating & Cooling

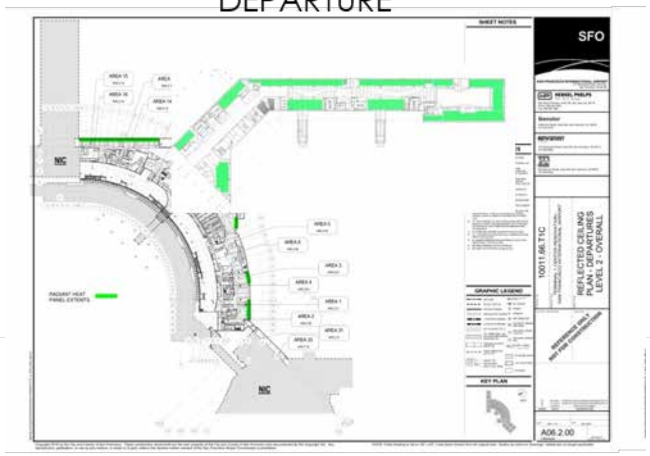


3. Radiant Heating and Cooling

3. Radiant Heating and Cooling

Hold Rooms

DEPARTURE



Commissioning, Activation, Simulation

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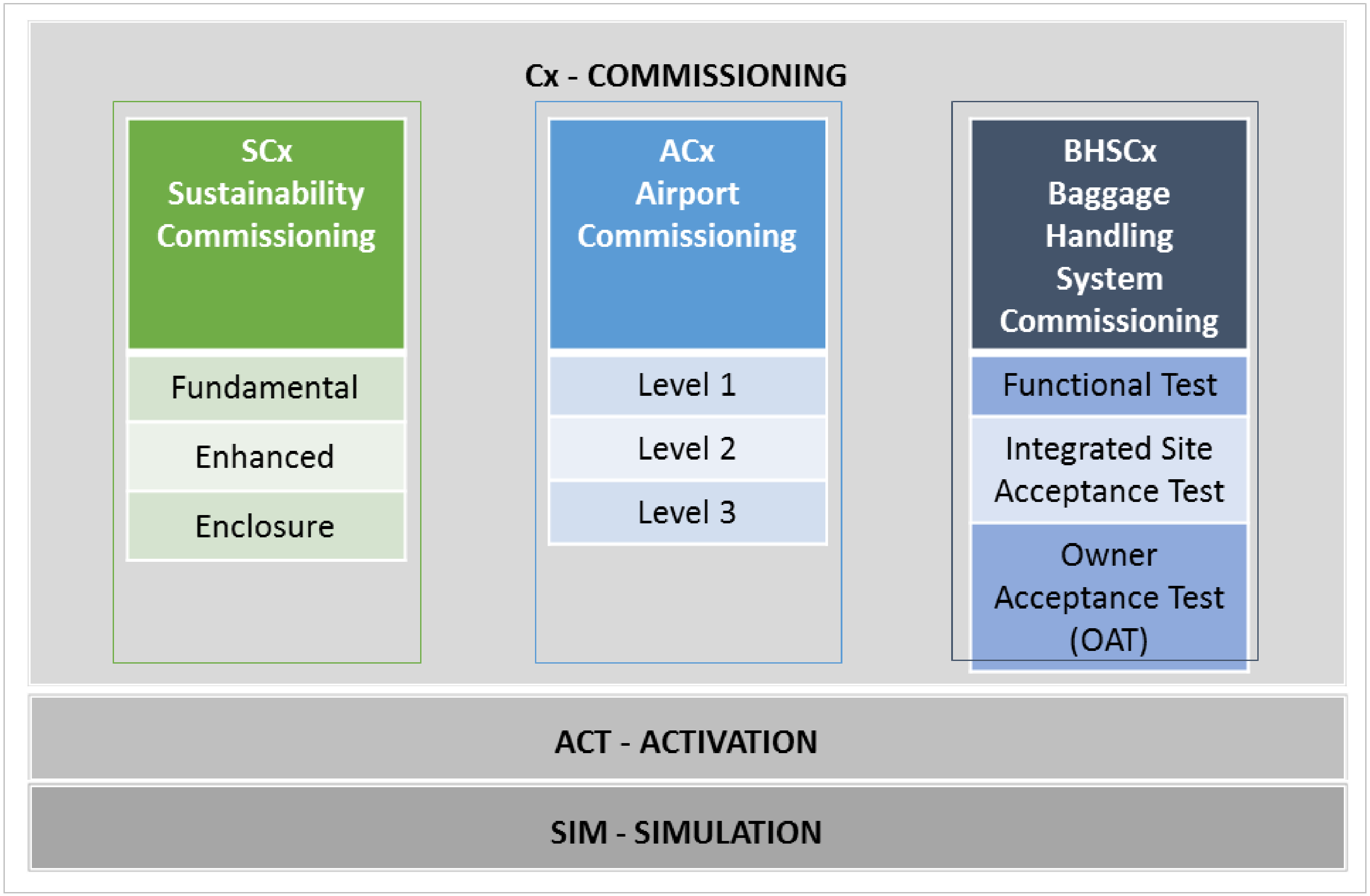
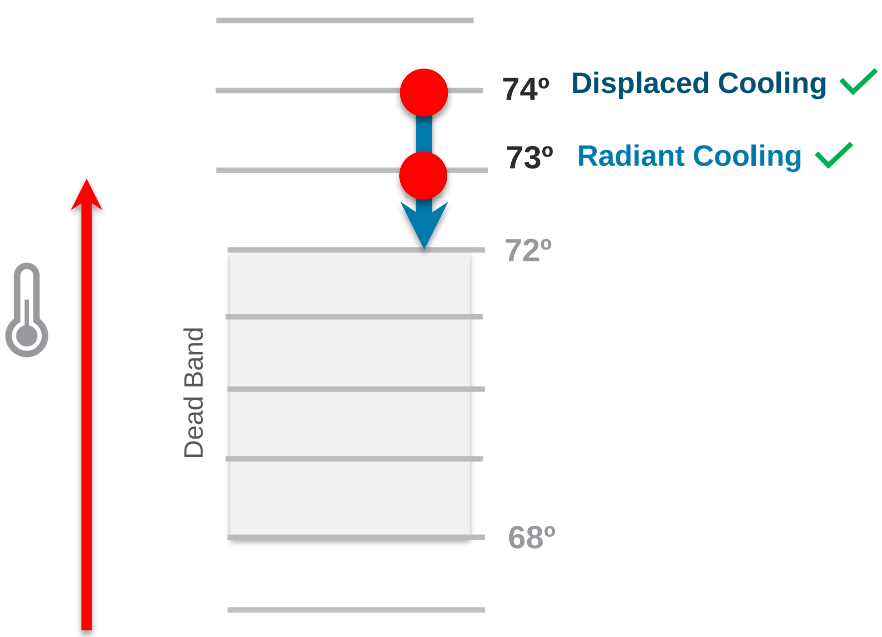
5. Commissioning, Activation, Simulation (ORAT)

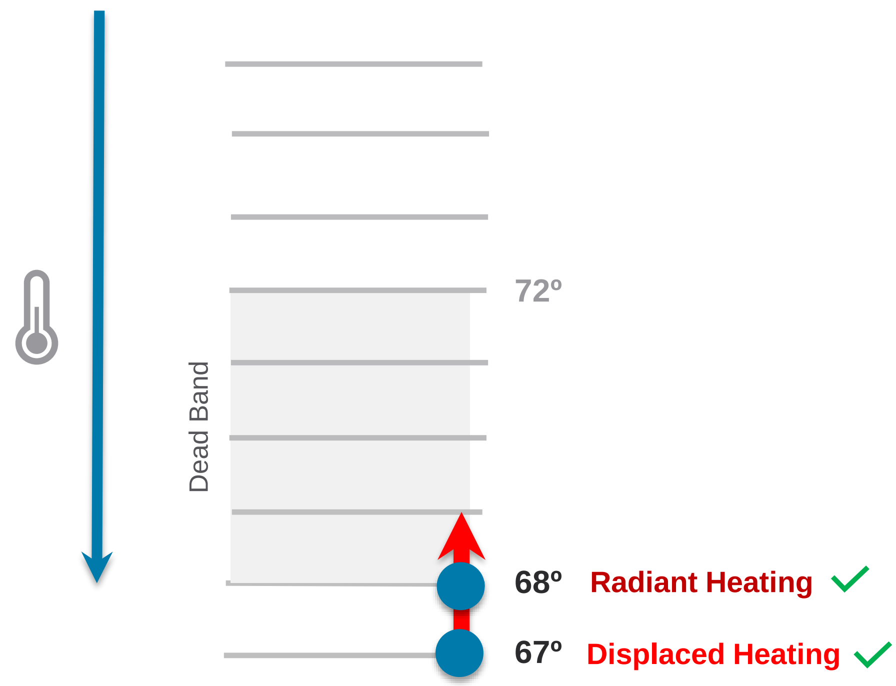


5. Commissioning – Fine Tuning

Rising Temperatures Trigger Cooling



Falling Temperatures Trigger Heating



5. Operational Readiness & Transition: Trials, Training, Simulation

Cost and Benefits

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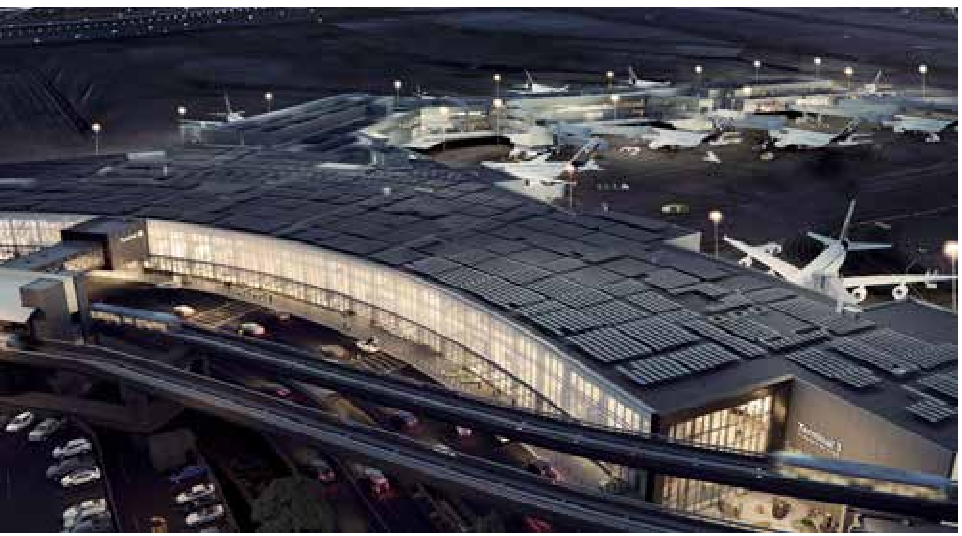

4. Triple Bottom Line Cost Benefit Analysis

SFPUC Hydro Electric Power

	Financial NPV		Social & Environmental NPV		Sustainable NPV	Sustainable BCR
Green Roof	-$1,052,555	+	$6,340,104	=	5,287,549	4.07
Electrochromic Glazing	-$3,287,126	+	$6,255,624	=	2,968,498	1.90
Motorized Window Shades	-$7,593,481	+	$6,255,624	=	-1,337,857	0.84
Interior Landscaping	-$8,480,450	+	$11,392,549	=	2,912,099	1.34
Radiant Heating and Cooling	-$2,134,000	+	$2,205,800	=	71,800	1.01
Ground Source Heat Pump	-$5,821,573	+	$594,152	=	-5,227,421	0.40

PG&E Power

Radiant Heating and Cooling	-$2,134,000	+	$2,523,400	=	389,400	1.06

Benefit Cost Ratio (BCR) **Benefit cost ratio (BCR):** Total projected future benefits divided by the total costs of the project, discounted to current dollars. A BCR between 0 and 1 indicates costs exceed benefits, while a ratio greater than one indicates benefits exceed costs.

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4. Triple Bottom Line Cost Benefit Analysis

Cost/Benefit Category	Present Values ($)	
Pollutants from Natural Gas Use	685,800	Social and Environmental
Carbon Emissions from Natural Gas Use	1,520,000	Social and Environmental
Capital Expenditures	(6,500,000)	Financial
Electricity Costs	1,198,000	Financial
Natural Gas Costs	3,168,000	Financial

2,945.5
Potential Houses Powered by the Electricity Saved

214.07
Cars Off The Road

CO_2 48,251
Tonnes of CO2 Equivalents Avoided

NO_X 109,213
Pounds of NOX Avoided

$PM_{2.5}$ 5,053
Pounds of PM2.5 Avoided

SO_2 532
Pounds of SO2 Avoided

VOC 4,876
Pounds of VOC Avoided

Q&A

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Thank you