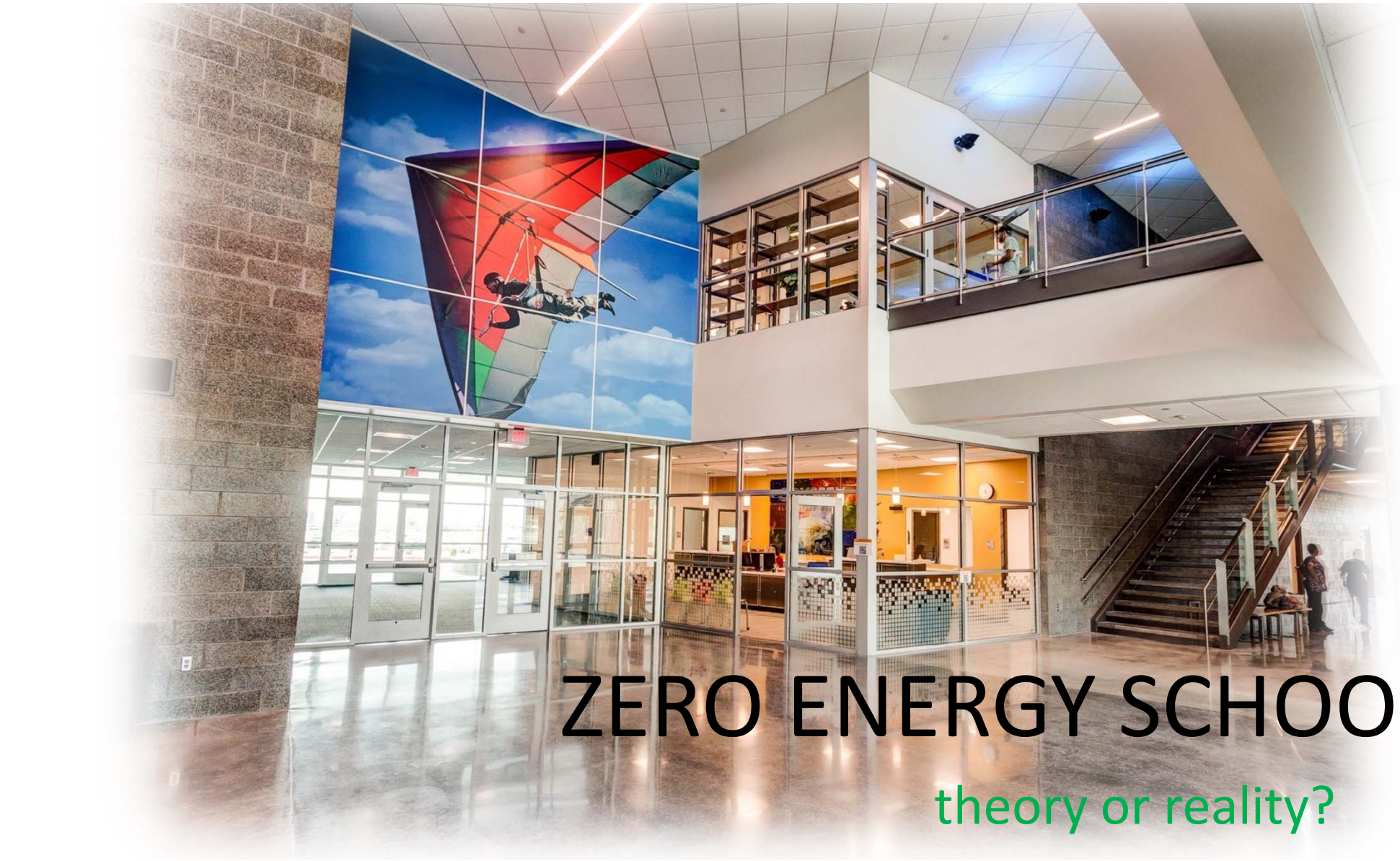


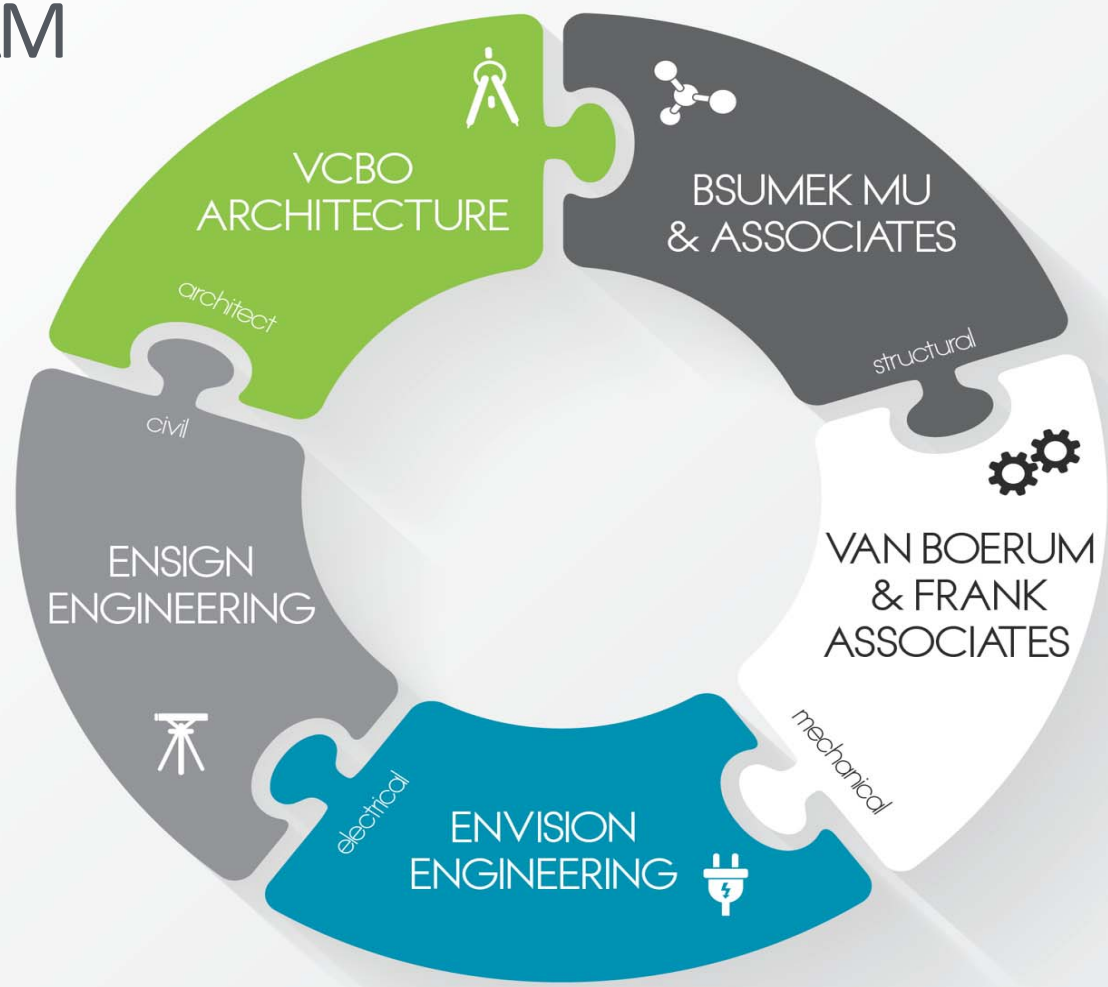
ZERO ENERGY SCHOOLS

theory or reality?

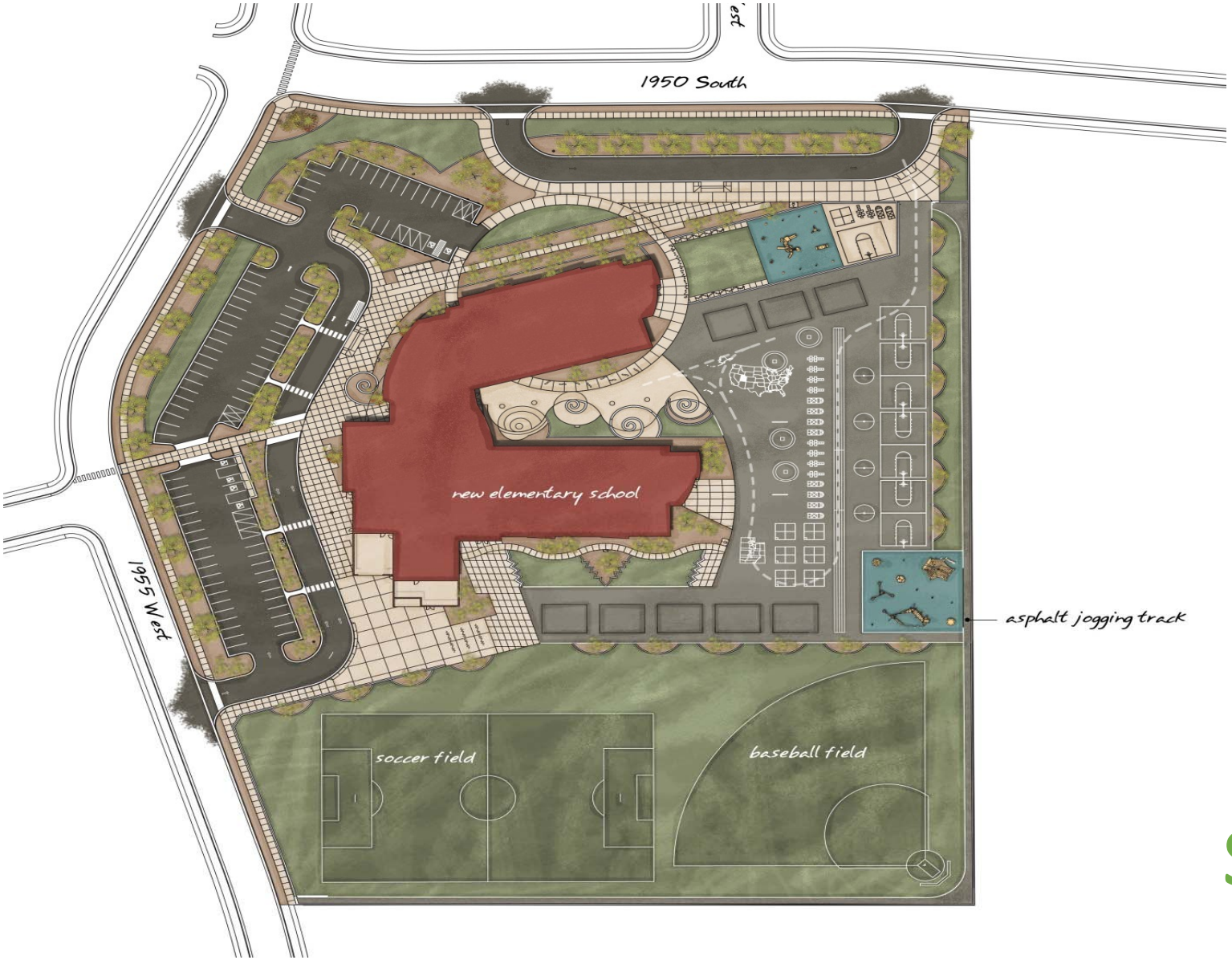
Agenda

- Zero Energy Building Design and Concept
- Zero Energy Building Reality
- The Final Piece PV
- Cost Implications + Payback

design TEAM


VCBO
ARCHITECTURE
architect
BSUMEK MU
& ASSOCIATES
structural
VAN BOERUM
& FRANK
ASSOCIATES
mechanical
ENVISION
ENGINEERING
electrical
ENSIGN
ENGINEERING
civil

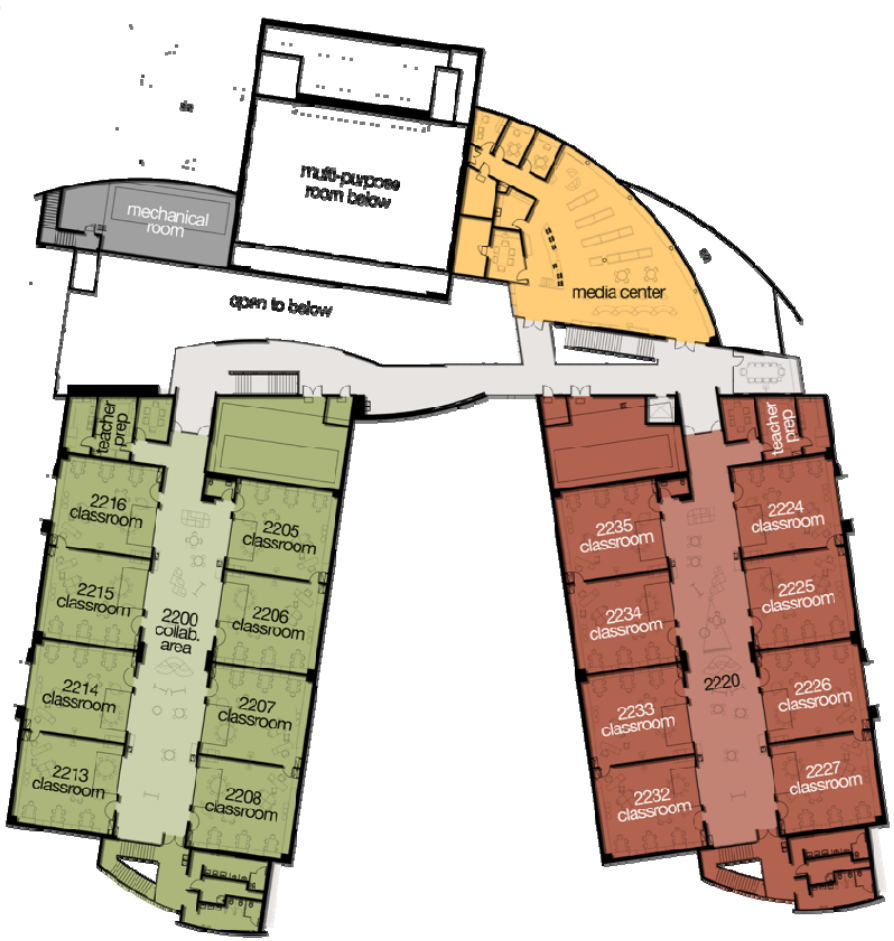

ODYSSEY ELEMENTARY SCHOOL
2050 SOUTH 1955 WEST


1950 South
1975 West
new elementary school
asphalt jogging track
soccer field
baseball field

site

main level

upper level



Zero Energy Building:
DESIGN & CONCEPT

DECISION MEETING

energy COST

- Average Building $1.00 / ft^2/yr
- Davis Average School Building $ .69 / ft^2/yr
- Odyssey Model $ .44 / ft^2/yr

electrical energy CONSERVATION MEASURES

- LED lighting - Lighting power density of .6 W/SF (IECC max allowable is 1.2 W/SF)
- Skylights w/glare control – 2nd Level collaboration spaces, commons areas, and multi-purpose room
- Lighting Control System – Occupancy sensors, daylight harvesting, dimming, and scene control
- Task tuning and lumen maintenance
- Lighting Controls Commissioning and Retro-commissioning
- Transformers – Aggressively sized, energy efficient, energy efficient at lower loading levels
- Wiring System – Shared neutrals in lieu of dedicated neutrals
- Plug Load Switching – Computer classrooms, vending machines, and drinking fountains
- Treated the power quality of the facility.

mechanical energy CONSERVATION MEASURES

- Improved Envelope
- Ground Source Heat
- Thermal Displacement Air Distribution
- Heat Recovery of Ventilation Air
- Economizer Cooling
- Ground Loop Free Cooling
- IDEC Cooling
- Demand-Limiting Boiler
- Demand-Controlled Ventilation

savings

- Lighting savings

- Better building insulation
  - Roof
  - Walls
  - Windows
  - Leakage

- Heating energy use savings

- Eliminated refrigerated cooling

EXCEPTIONALLY LOW ENERGY USE

=

fewest PV panels needed

Zero Energy Building:
REALITY

WHAT IS A zero energy building

U.S. Department of Energy (DOE) Releases "A Common Definition of Zero Energy Buildings" which states:

…a Zero Energy Building (ZEB) is *"an energy-efficient building where, on a source basis, the actual delivered energy is less than or equal to the on-site renewable exported energy"*

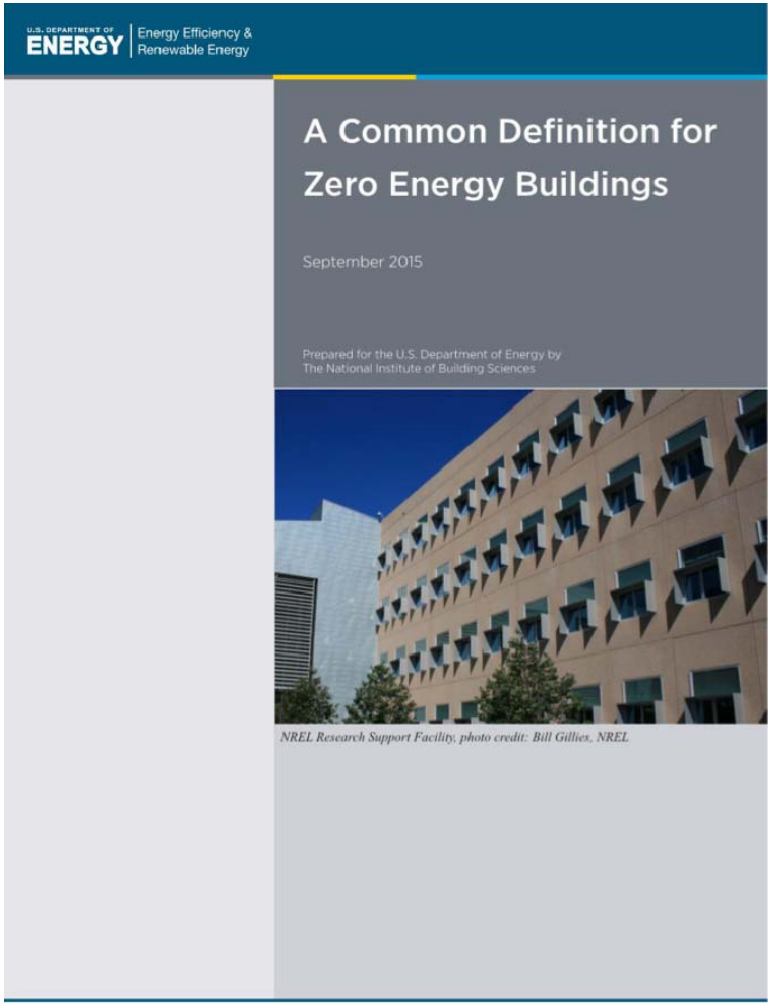


Table 1 – National Average Source Energy Conversion Factors

Energy Form	Source Energy Conversion Factor (r)
Imported Electricity	3.15
Exported Renewable Electricity	3.15
Natural Gas	1.09
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.19
Propane & Liquid Propane	1.15
Steam	1.45
Hot Water	1.35
Chilled Water	1.04
Coal or Other	1.05

Source energy would be calculated using the following formula:

$$E_{source} = \sum_i (E_{del,i} r_{del,i}) - \sum_i (E_{exp,i} r_{exp,i})$$

Where

$E_{del,i}$ is the delivered energy for energy type i;

$E_{exp,i}$ is the exported on-site renewable energy for energy type i;

$r_{del,i}$ is the source energy conversion factor for the delivered energy type i;

$r_{exp,i}$ is the source energy conversion factor for the exported energy type i;

Odyssey Elementary 12 month data

		elec kwh use	gas dth use	PV production	
	Oct	23520	28	44240	
	Nov	23880	20	28920	
	Dec	34400	51	21360	
	Jan	21520	42	5960	
	Feb	25840	41	8720	
	Mar	34200	38	26760	
	Apr	26560	31	34960	
	May	24680	18	51640	
	Jun	19720	10	56440	
	Jul	13000	6	56280	
	Aug	16360	5	66360	
	Sep	19840	8	51120	
	Total	**283520**	**298**	**452760**	
		source elec kbtu	**source gas kbtu**	**site renewable kbtu**	**Net kbtu**
ZEB calc		3045430	324820	4863322	-1493071

Review of Odyssey Elem Energy 12 months

October 2014 through September 2015

	Building Square Feet	Site EUI Kbtu/sq.ft.	Metric Tons CO2 Emmissions/ 1000 sq.ft.	ECI Cost/sq.ft. *	Metric Tons CO2 Emmissions	Metric Tons CO2 Emmissions after PV offset
Energy Model Elem 60 Design Building	86,898	21.8	3.87	$0.48	336	17
Odyssey actual usage	84,758	17.1	2.88	$0.36	244	-75
Energy Model Elem 60 Baseline (code bldg)	86,898	43.8	6.05	$0.77	526	526

** Costs are before PV and based on Utah Average Cost per Energy Information Administration (EIA)*

Review of 3 New Schools12 months with PV

	Building Square Feet	Site EUI Kbtu/sq.ft.	Cost/sq.ft.			
Odyssey Elem	84,758	3.34	$0.20			
Canyon Creek Elem*	84,758	12.33	$0.48			
Kay's Creek Elem*	84,758	20.74	$0.32			

** Not a full year of PV production.*

The Final Piece:

PHOTOVOLTAIC ARRAY

lessons learned & PITFALLS TO AVOID

Paying for the Photovoltaic Array

Sizing the Photovoltaic Array

Additional Equipment/Hidden Costs

Control Issues

cost implications + PAYBACK

cost IMPLICATIONS

Typical Elementary School

Mechanical Cost / SF:	$25.50
Electrical Cost / SF:	$23.10
Cost to Operate:	$1.00 / SF / Year
Total Cost First Year:	$80,000 / Year

cost IMPLICATIONS

Typical Davis School District Elementary School

Mechanical Cost / SF: $25.80
Electrical Cost / SF: $19.90

Cost to Operate: $0.79 / SF / Year
Total Cost First Year: $59,150 / Year

cost IMPLICATIONS

Endeavour Elementary School

Mechanical Cost / SF: $29.40
Electrical Cost / SF: $19.90

Cost to Operate: $0.59 / SF / Year
Total Cost First Year: $44,150 / Year

DA1

cost IMPLICATIONS

Odyssey Elementary School

Mechanical Cost / SF: $35.40
Electrical Cost / SF: $19.80

Model

Cost to Operate: $0.44 / SF / Year
Total Cost First Year: $37,268 / Year

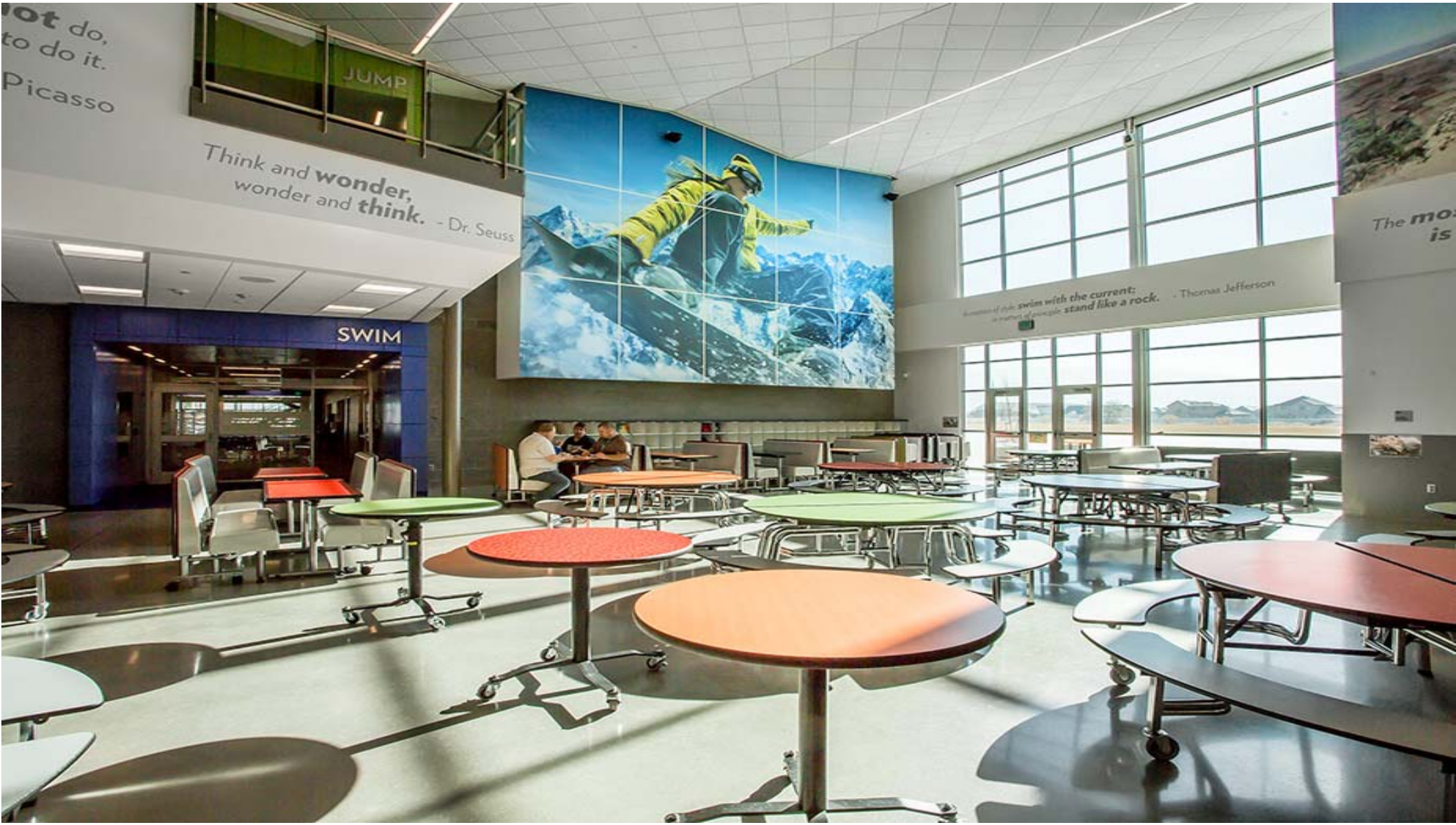
Actual

Cost to Operate: $0.36 / SF / Year
Total Cost First Year: $30,268 / Year

Slide 28

DA1 Doug Anderson, 9/11/2018


JUMP
EXIT


JUMP
Think and wonder, wonder and think. - Dr. Seuss
SWIM
- Thomas Jefferson

questions