



An Evolution of BIPV Design Tools

Modeling Architectural Solar Today

Browning Rockwell
Executive Director

Christopher Klinga, PE
Technical Director

April 12, 2018





Browning Rockwell – Executive Director

Over his 36-year career he has spanned a range of disciplines related to business development, international business, and project and technical management. He has founded and led several not for profit associations including the Emirates Solar Industry Association (ESIA), Saudi Arabia Solar Industry Associations (SASIA) and Solar GCC Alliance aimed at furthering the growth of solar energy in the Middle East



Christopher Klinga P.E. - Technical Director

A 10 year veteran to the solar industry with an extensive background in solar installation design and operations as well as architectural solar product development. Chris is a licensed professional structural engineer. In addition to his efforts with ASA he operates his own solar product development firm SolMotiv Design where he consults directly with the full value chain of both the PV and curtain wall industries. Chris is a co-inventor on 3 solar technology patents as well as 3 pending patents. Chris holds a B.S. in Mechanical Engineering from the University of Colorado in Boulder.

ASA Management



The ASA Mission

The **Architectural Solar Association (ASA)** is an industry advocate for standards development, education, legislative regulations, building & energy codes and solar architecture design specification as they relate to integrating solar into architectural design.

We represent a growing industry with a common goal of transforming building facades and other architectural surfaces into generating assets.



ASA Goals

Standard Development

A lack of clear building standards are a major barrier to integrating solar architecturally. By harmonizing the UL 1703 standard with IEC standards we will see changes that benefit the architectural solar market.

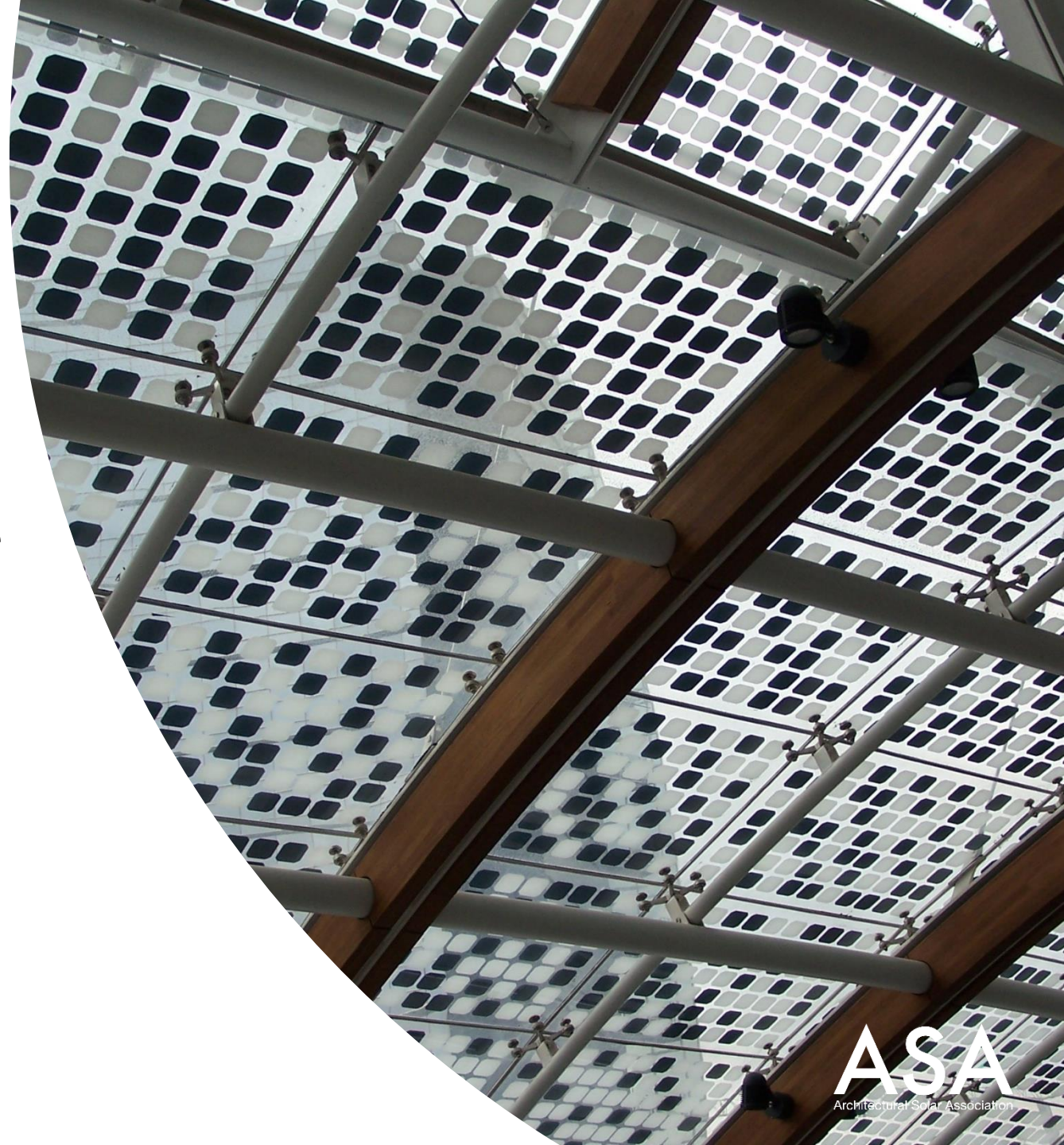
Specific Architectural Solar standards also need to be developed.

Raise Awareness

There is currently a lack of industry relevant education for design professionals. By empowering design professionals the industry will rapidly progress. Product companies need to actively integrate with the design process through education and BIM content.

Building Industry Adoption

The global building industry and the solar industry have yet to fully integrate. Solar needs to be a ubiquitous resource to all building professionals.



Architectural Solar Benefits

- Sustainability Awareness
- Increases distributed energy generation potential.
- Capable of serving multiple design intents.
 - Visually & Functionally
- Capable of reducing cooling load through shading.
- Manufacturing and installation costs can be analyzed on an incremental level.

Why is the Market Ready for BIPV?

A modern building with a blue and white pixelated facade, situated on a pier over water. The building has a unique, stepped design with many windows. The sky is blue with some clouds. The water in the foreground is dark blue.

Compelling BIPV Economics

- Steep \$/W cost reductions
- Competitive incremental cost
- Compelling payback
- Tax credits / Depreciation Savings
- BIPV based incentives
- Higher lease rates and valuation.

Trending Tail Winds

- Government BIPV Regulations
- Net Zero Buildings
- Green Building Incentives
- Strong Desire for Sustainability

Overview

- Definition of BIPV & Architectural Solar
- Multi-Functional Attributes of Architectural Solar
- The Evolution of PV Software & BIPV
- Today's & Tomorrow's BIPV Workflow
- The Lumina Case Study
- BIMSolar Overview and Lumina Example

Definition of BIPV per EN 50583

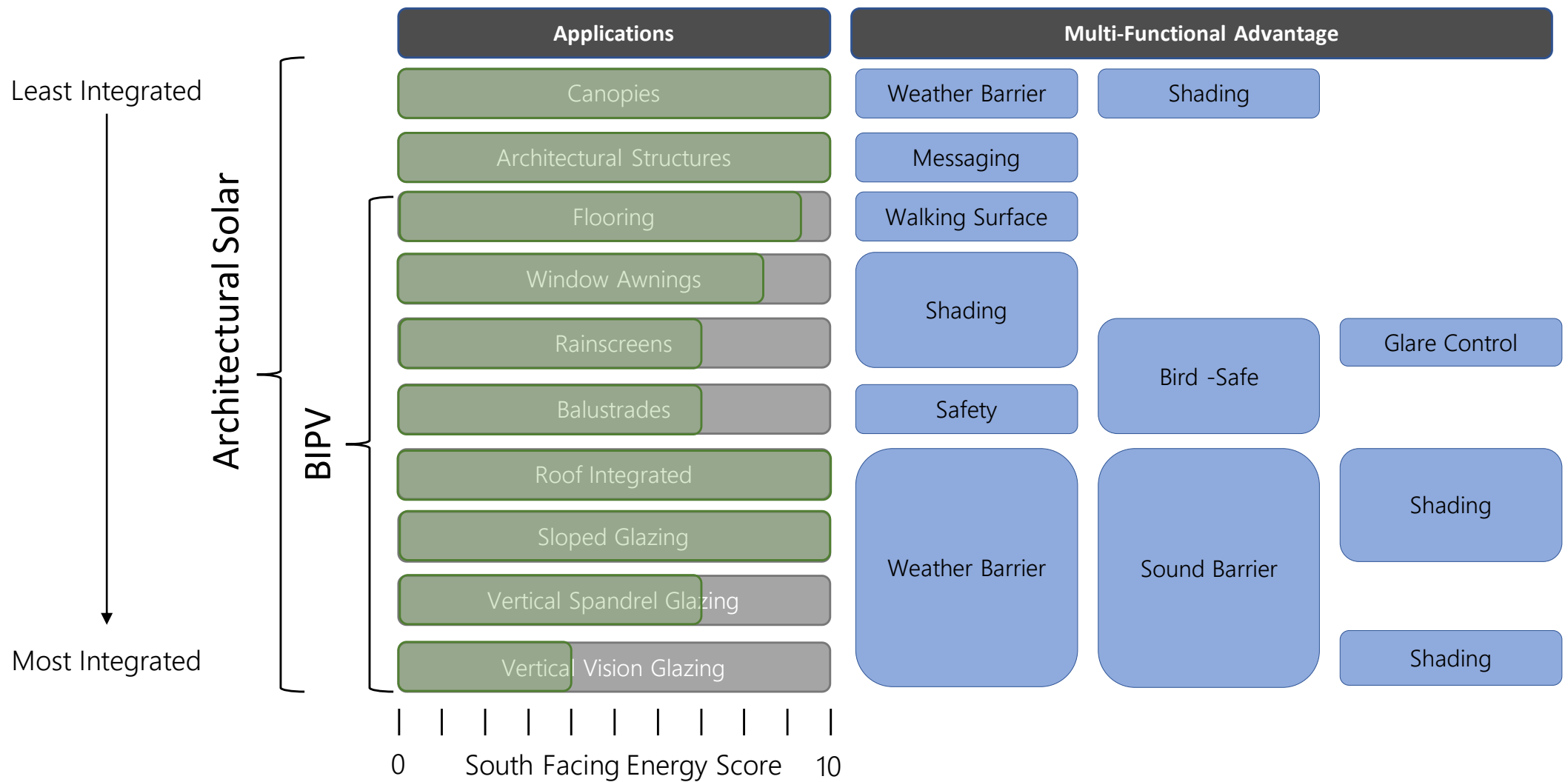
Building Integrated Photovoltaic modules (BIPV) are considered to be building-integrated, if the PV modules form a construction product providing a function as defined in the European Construction Product Regulation CPR 305/2011. Thus the BIPV module is a prerequisite for the integrity of the building's functionality. If the integrated PV module is dismounted, the PV module would have to be replaced by an appropriate construction product.

Building Function

- Mechanical rigidity or structural integrity
- Primary weather impact protection: rain, snow, wind, hail
- Energy economy, such as shading, daylighting, thermal insulation
- Fire protection
- Noise protection
- Separation between indoor and outdoor environments
- Security, shelter or safety



BIPV / Architectural Solar Solar Technologies with Architectural Significance



Architectural Applications

The Evolution of BIPV Software

Today's BIPV Workflow From CAD to Cost Analysis



Natural Resources
Canada

CanmetENERGY
Leadership in ecoInnovation



PV*SOL premium

Solar Pro
Photovoltaic System Simulation Software

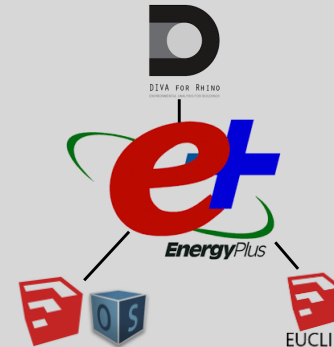


\$

Free



SYSTEM
ADVISOR
MODEL



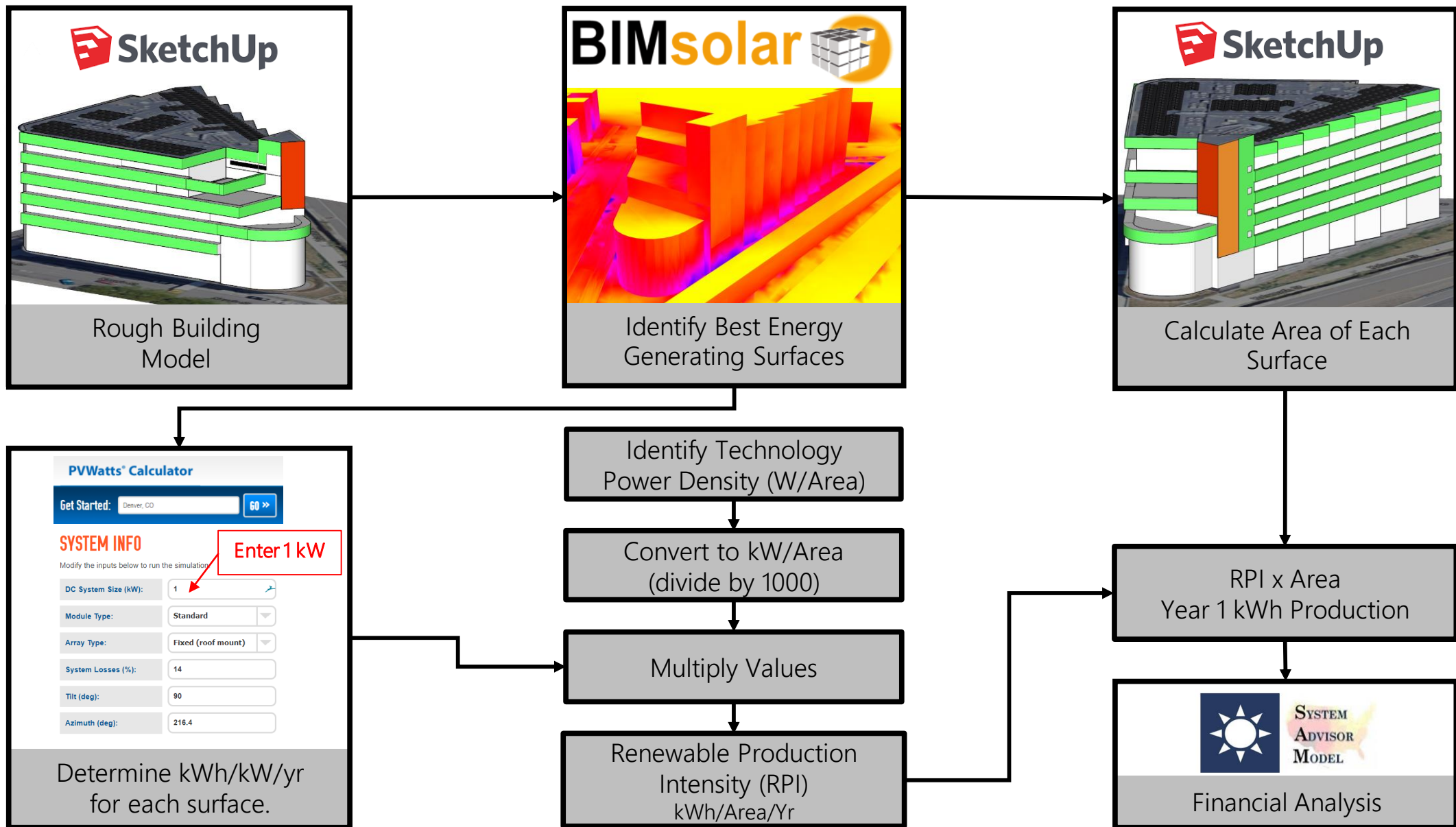
PV Analysis Only

PV & Building Thermal Analysis

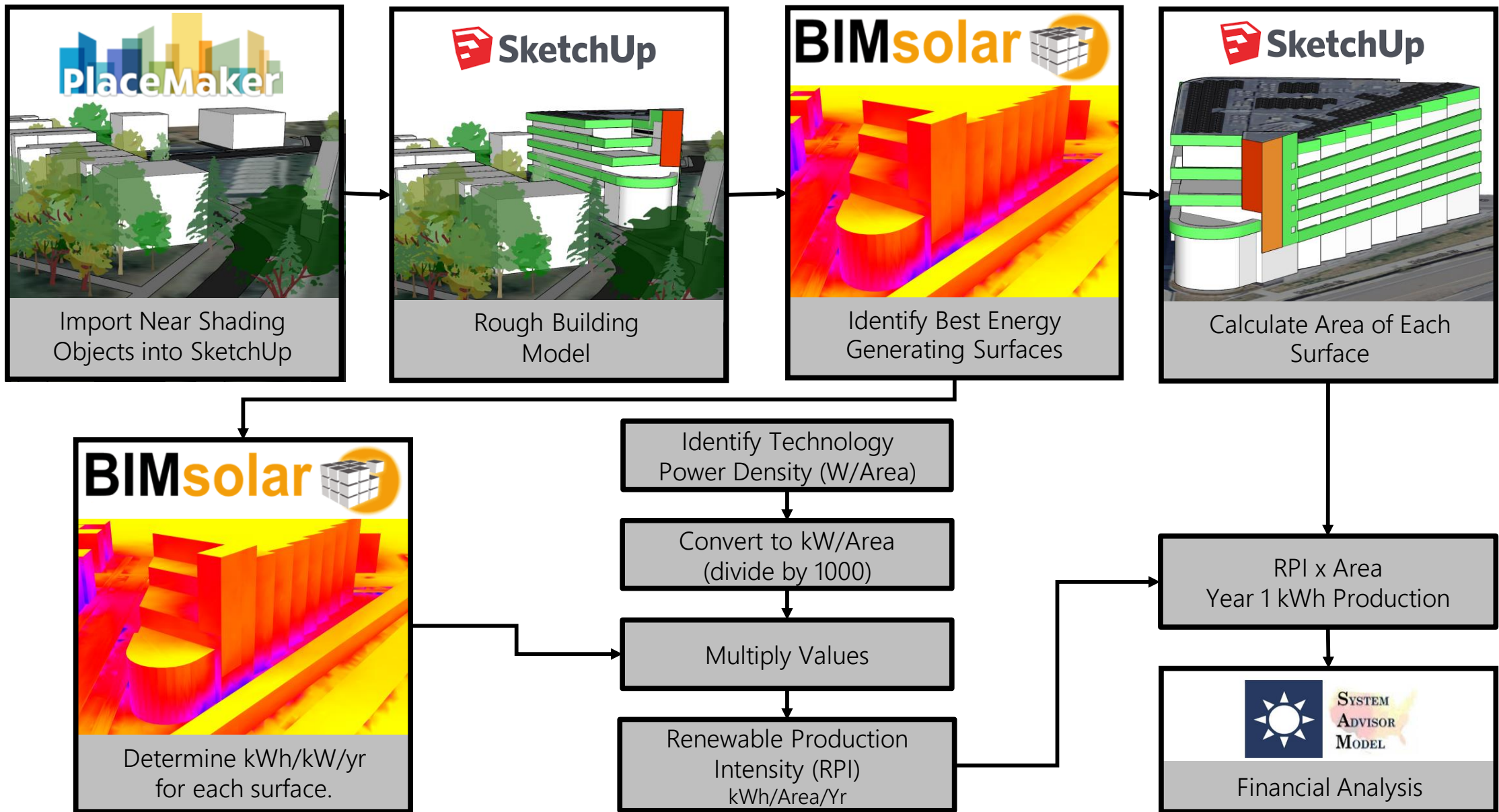
BIM PV & Thermal Analysis

BIPV Software Research In Progress:
NRCAN is currently analyzing these 8
BIPV capable software platforms and
how they compare to a real world
BIPV installation on the first Net-Zero
Institutional building in Canada, the
Varenes Public Library.

BIPV Software Evolution



Early Stage BIPV Feasibility Workflow (no shading)



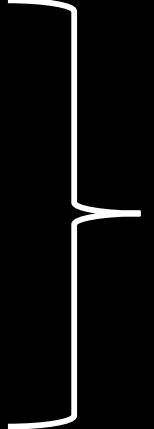
Early Stage BIPV Feasibility Workflow (with shading)

Tomorrow's BIPV Workflow

Fully Integrated Analysis via
Building Information Modeling (BIM)

High Priority Functionality

- PV Performance with Shading
 - EUI based Energy Offset Approximations
 - Basic Financial Analysis
- 
- Today

- Multi-CAD platform BIM Integration
 - Thermal Benefits
 - Daylighting Impact
 - Glare Hazard
- 
- Future

The Lumina Case Study



Project Profile : Lumina

Location: Denver, CO

Completed : May 2015

Floor Area: 107,361 sqft

Height: 5 Floors

Type: Mixed Use Apmts
61 units

PV System: 20.75 kW Lumos LSX PV Screenwall



Building Owner: TreeHouse Development



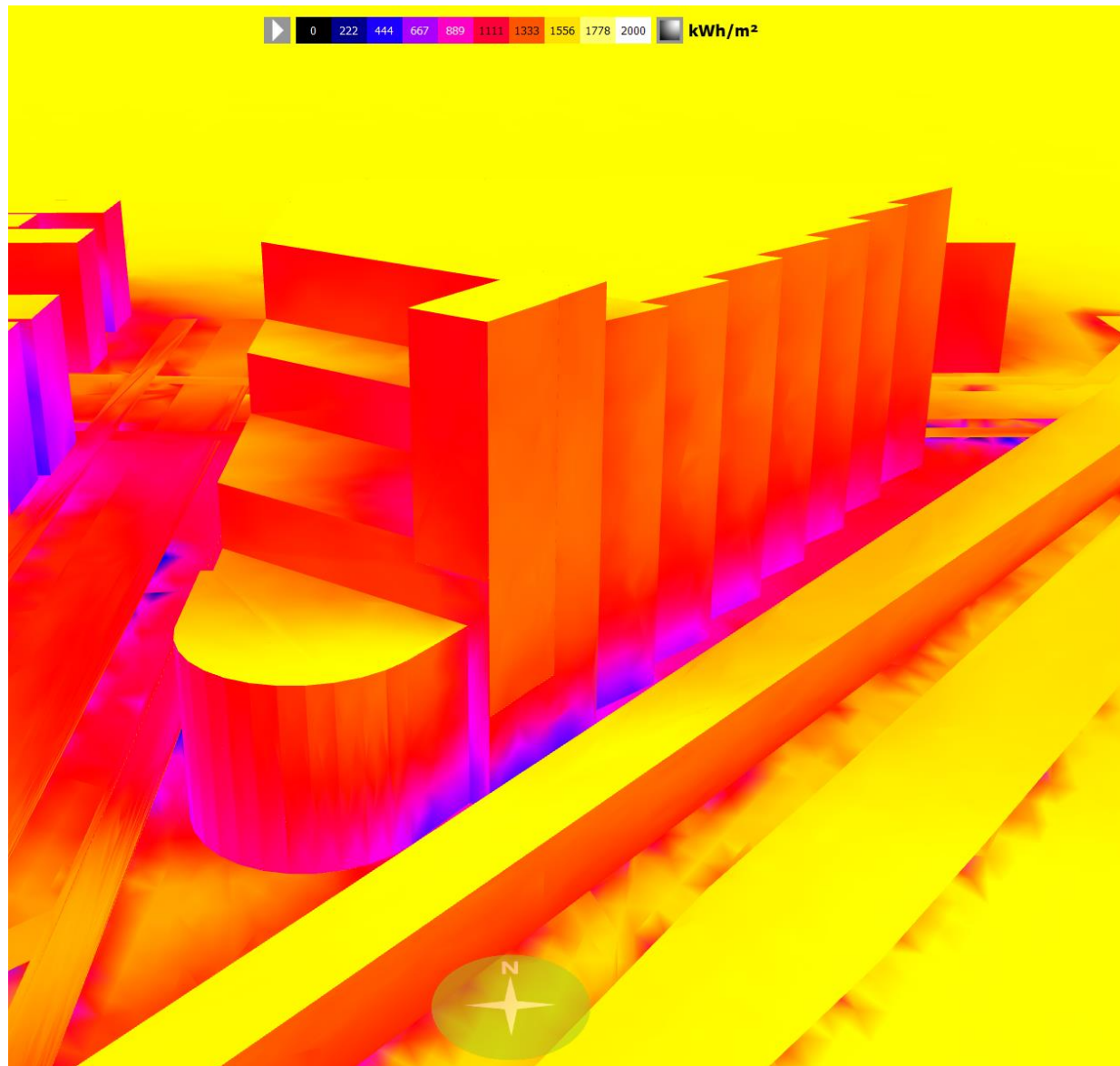
Architect: Tres Birds Workshop 

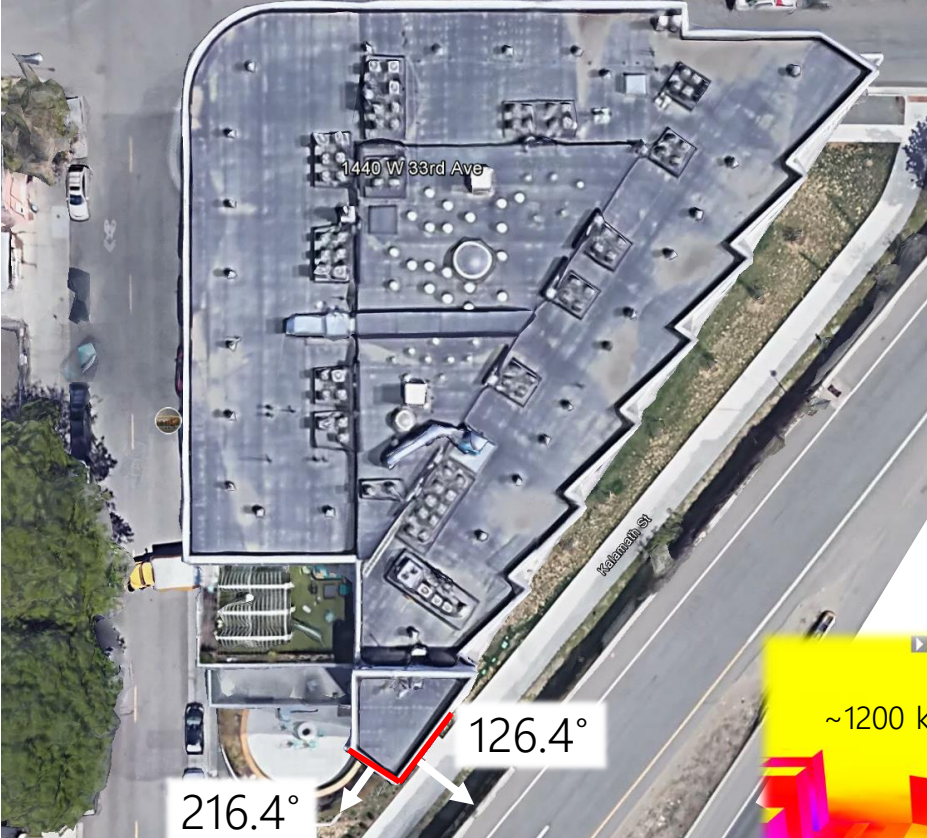
General Contractor: JHL Constructors



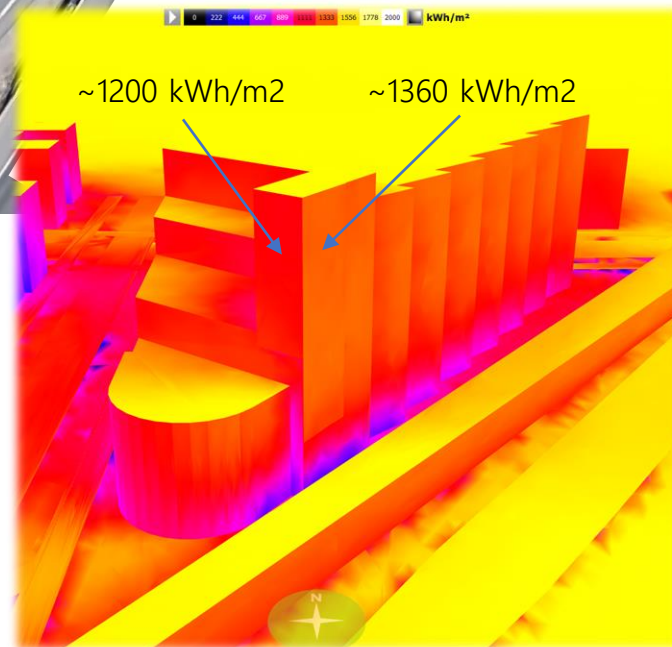
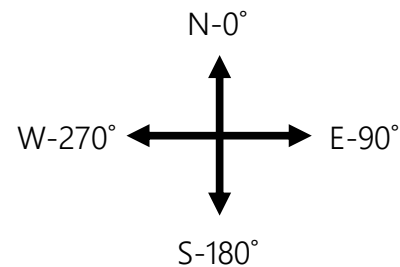
PV Installer: ARE Solar



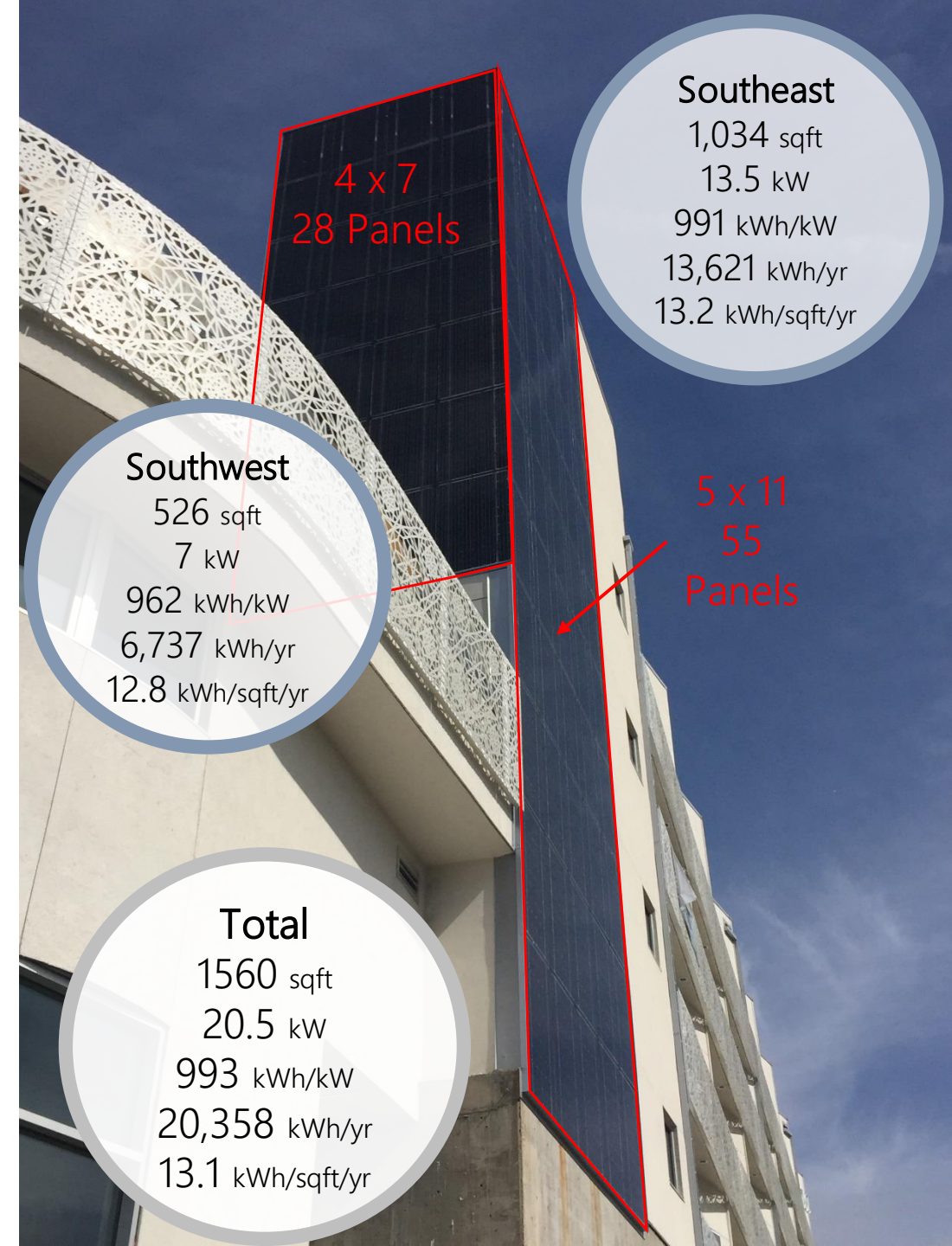




Total Floor Area
107,361 sqft



System Overview



Southeast
1,034 sqft
13.5 kW
991 kWh/kW
13,621 kWh/yr
13.2 kWh/sqft/yr

Southwest
526 sqft
7 kW
962 kWh/kW
6,737 kWh/yr
12.8 kWh/sqft/yr

**5 x 11
55
Panels**

**4 x 7
28 Panels**

Total
1560 sqft
20.5 kW
993 kWh/kW
20,358 kWh/yr
13.1 kWh/sqft/yr

Solar Module

LSX 250 (Now 285 Watts)

Racking System

LSX Rail 1.0

Inverter – SMA

(3) Sunny Boy 6000TL-US-22 208V

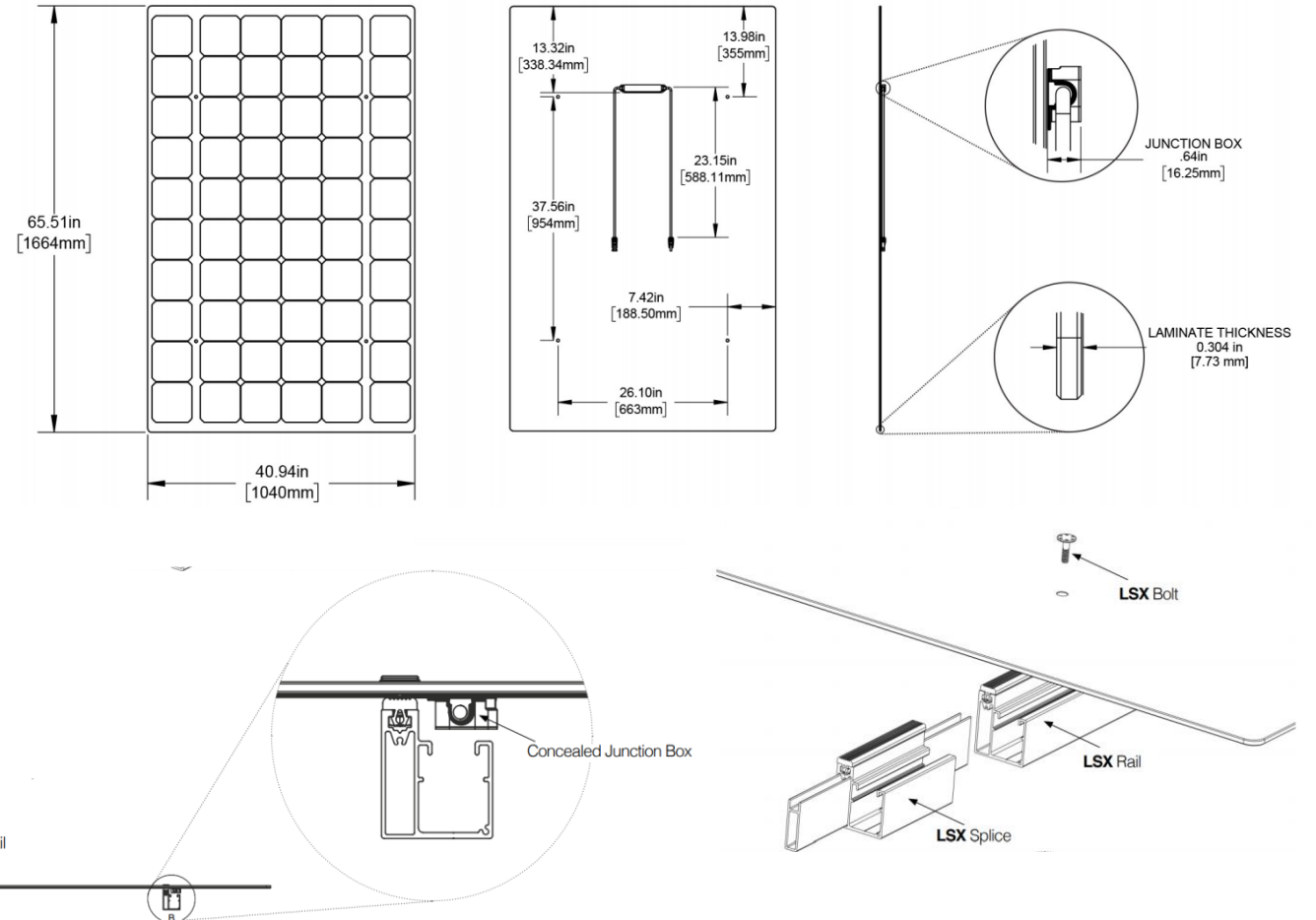
Technical data	Sunny Boy 6000TL-US	
	208 V AC	240 V AC
Input (DC)		
Max. usable DC power (@ cos φ = 1)	6300 W	
Max. DC voltage	600 V	
Rated MPPT voltage range	210 – 480 V	
MPPT operating voltage range	125 V – 500 V	
Min. DC voltage / start voltage	125 V / 150 V	
Max. input current / per MPPT tracker	30 A / 15 A	
Number of MPPT trackers / strings per MPPT tracker		
Output (AC)		
AC nominal power	5200 W	6000 W
Max. AC apparent power	5200 VA	6000 VA
Nominal AC voltage / adjustable	208 V / ●	240 V / ●
AC voltage range	183 – 229 V	211 – 264 V
AC grid frequency; range	60 Hz / 59.3 – 60.5 Hz	
Max. output current	25 A	
Power factor (cos φ)	1	
Output phases / line connections	1 / 2	
Harmonics	< 4%	
Efficiency		
Max. efficiency	96.8%*	97.1%*
CEC efficiency	96%*	96.5%*



LSX Module mounted to LSX Rail

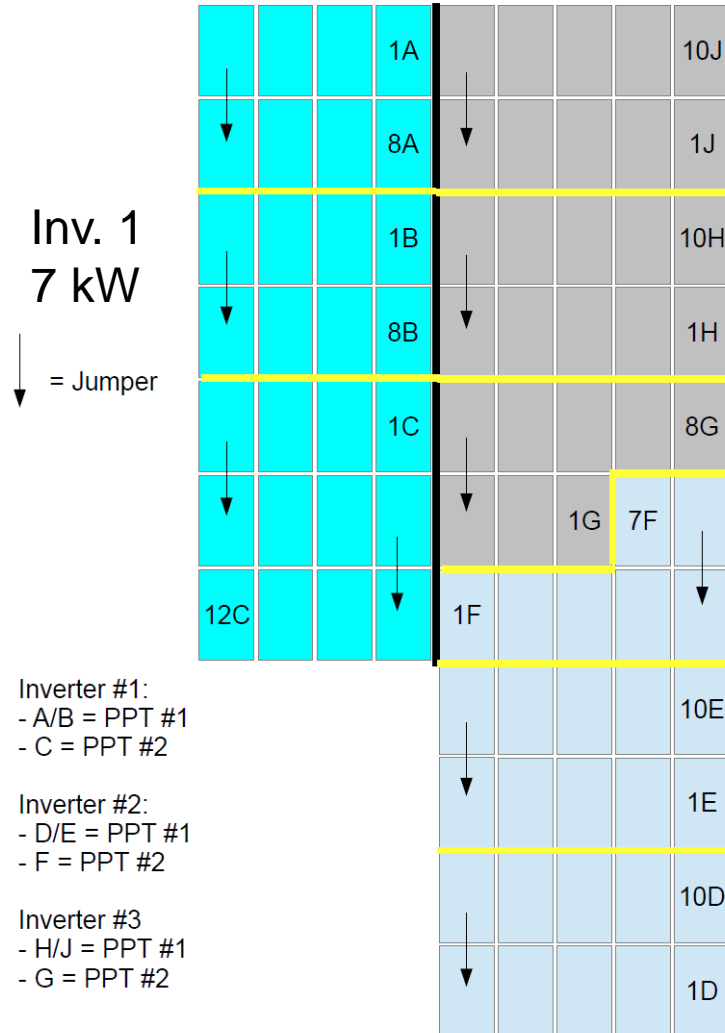
LSX Module System

LUMOS



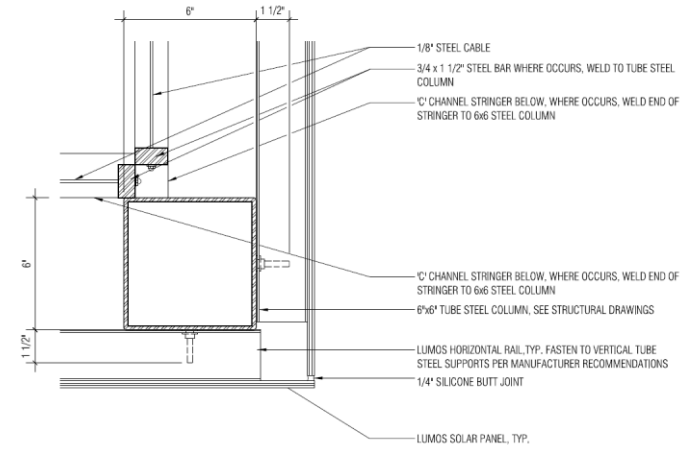
Equipment Specifications

Mounting & Wiring Spec

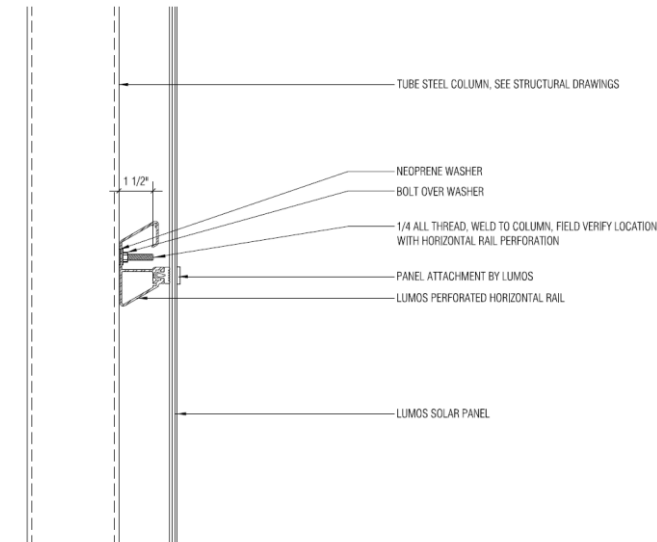


Inv. 3
7 kW

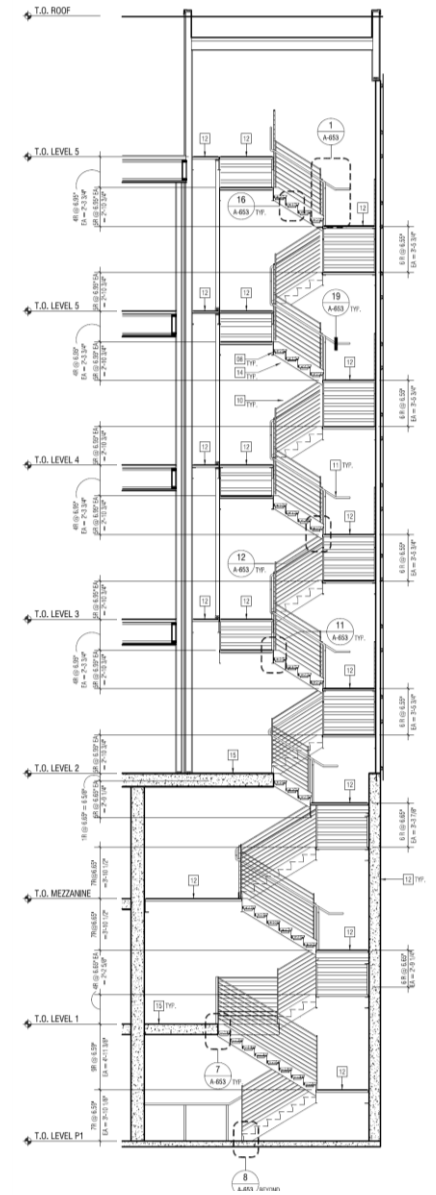
Inv. 2
6.75 kW



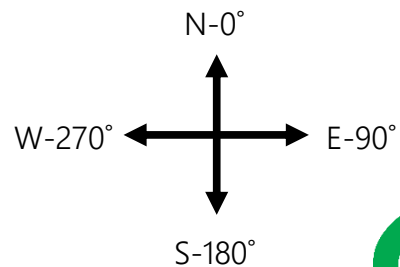
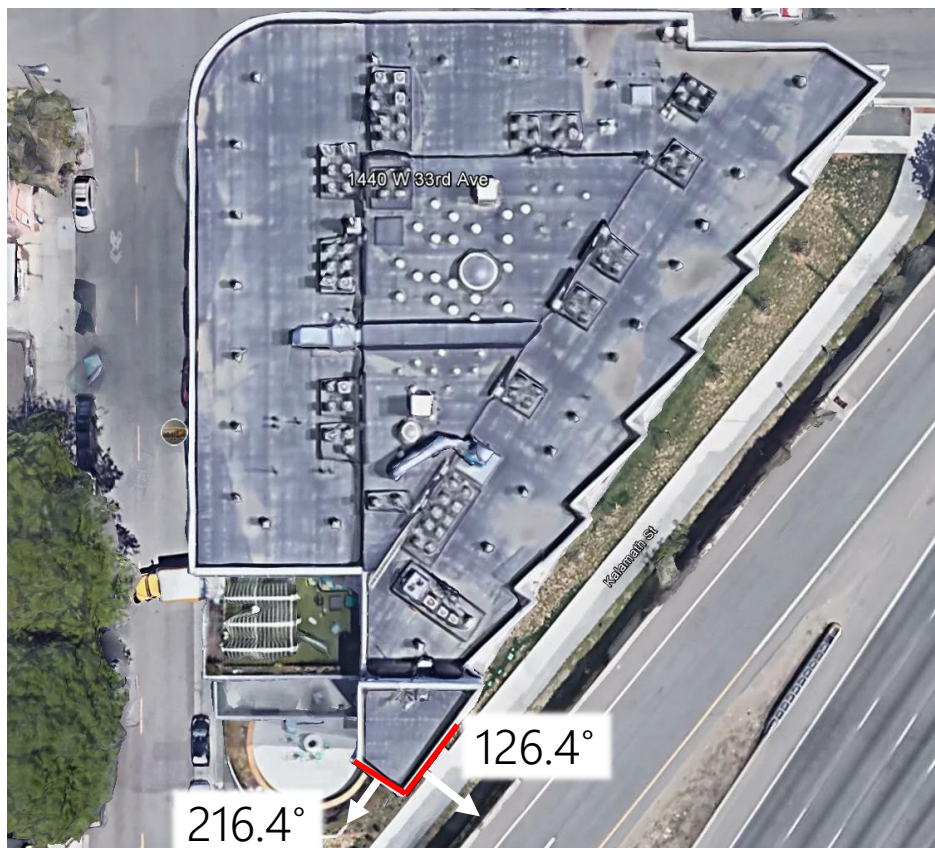
7 SOLAR WALL - PLAN
SCALE: 3" = 1'-0"



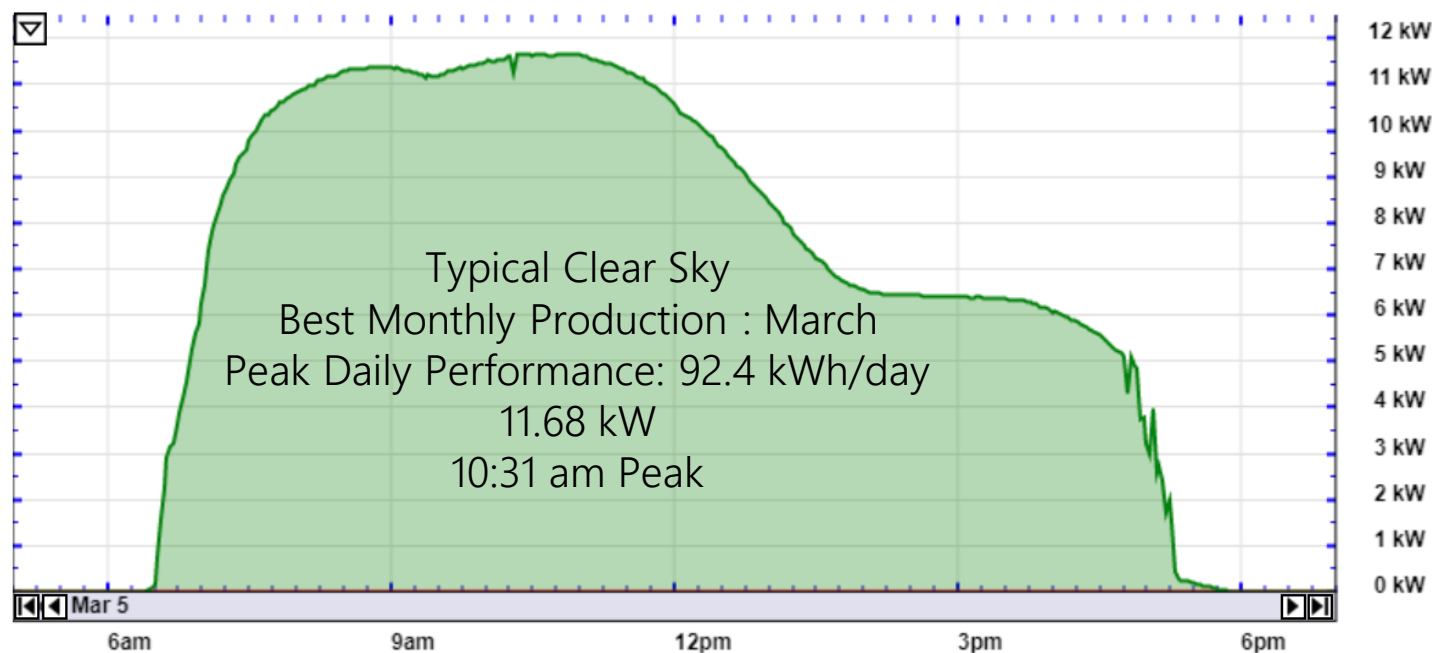
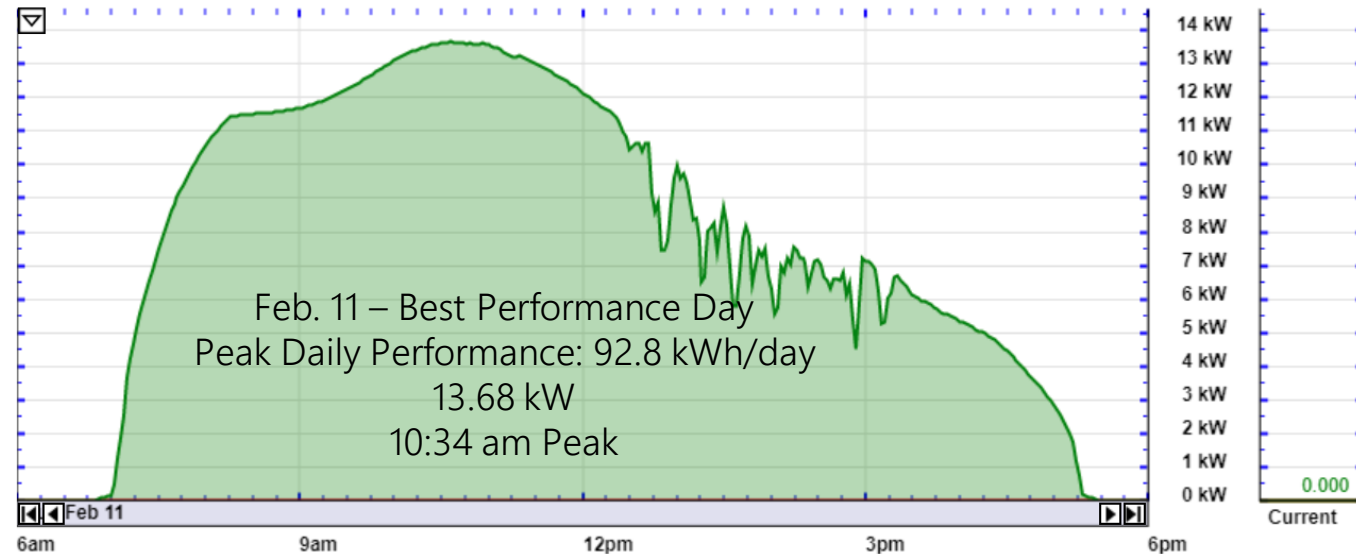
8 SOLAR WALL - PLAN
SCALE: 3" = 1'-0"



7 STAIR 2 SECTION
SCALE: 1/4" = 1'-0"

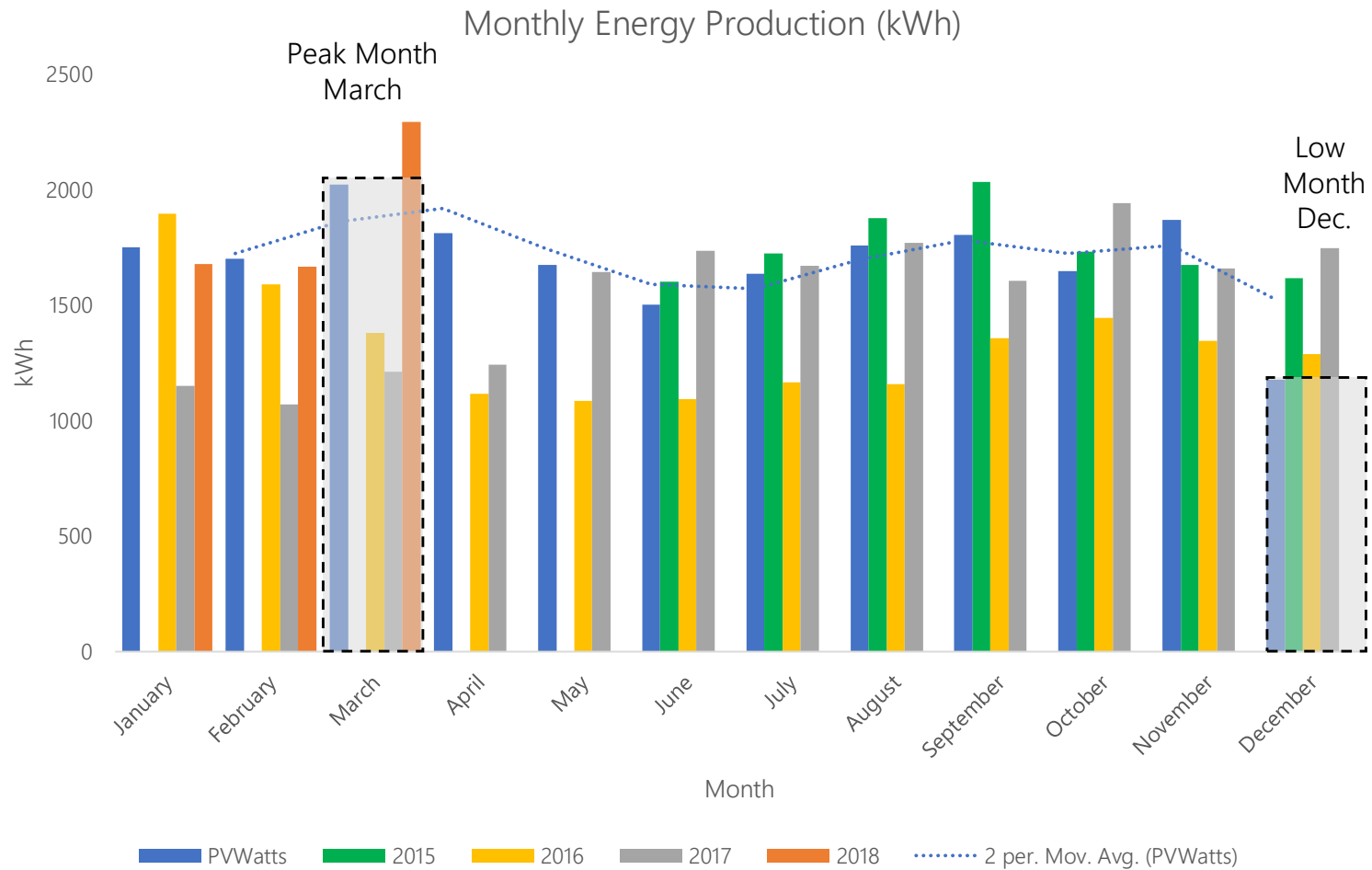


Lumina Production Data



PV Watts
Estimate
Year 1
20,360 kWh

0.5% Per Year
Degradation
De-rate
Year 3
20,056 kWh



Total
YTD
20,897 kWh
+ 4.2%

All Time Total
53,570 kWh
Down 9%
(As of March 22)

Note: Inverter down for March 2016 – Feb 2017. New maintenance staff failed to alert the solar installer.

Lumina Production Data



Affordable
Alternative
Energy

SOLAR INSTALLATION BID ESTIMATE

303.665.0006 : info@AAEpower.com : www.aeepower.com : Boulder, Colorado

Cost for this PV system

ITEM	PRICE
Materials cost: <i>including</i> - Panels, Inverters, Racking & Misc. Equipment	\$72,551.61
Sales tax	\$2,203
Xcel fees & City permit fees	\$2,100
Engineering	\$1,500
Monitoring	\$750
Freight	\$523
Install labor	\$14,228

Total System Cost	(Price per watt) \$4.62	\$93,855
--------------------------	--------------------------------	-----------------

Federal Tax Credit - 30% of TOTAL cost	(\$28,157)
--	------------

Net cost after Tax Credit	\$65,699
---------------------------	----------

Profit / ROI / Pay-Back

Xcel REC rebate payments to you over then next 20 years (Paid quarterly)	\$22,573
Estimated savings from 20 years of producing your own electricity	\$81,776
Estimated savings from accelerated depreciation	\$19,710
TOTAL ESTIMATED SAVINGS	\$124,058
*ROI (Return on Investment)	9.44%
*Pay-Back	10 Years, 8 Month

*20 yrs. Electrical Generation Savings:	\$81,776
*Your Net PROFIT after 20 years	\$58,360

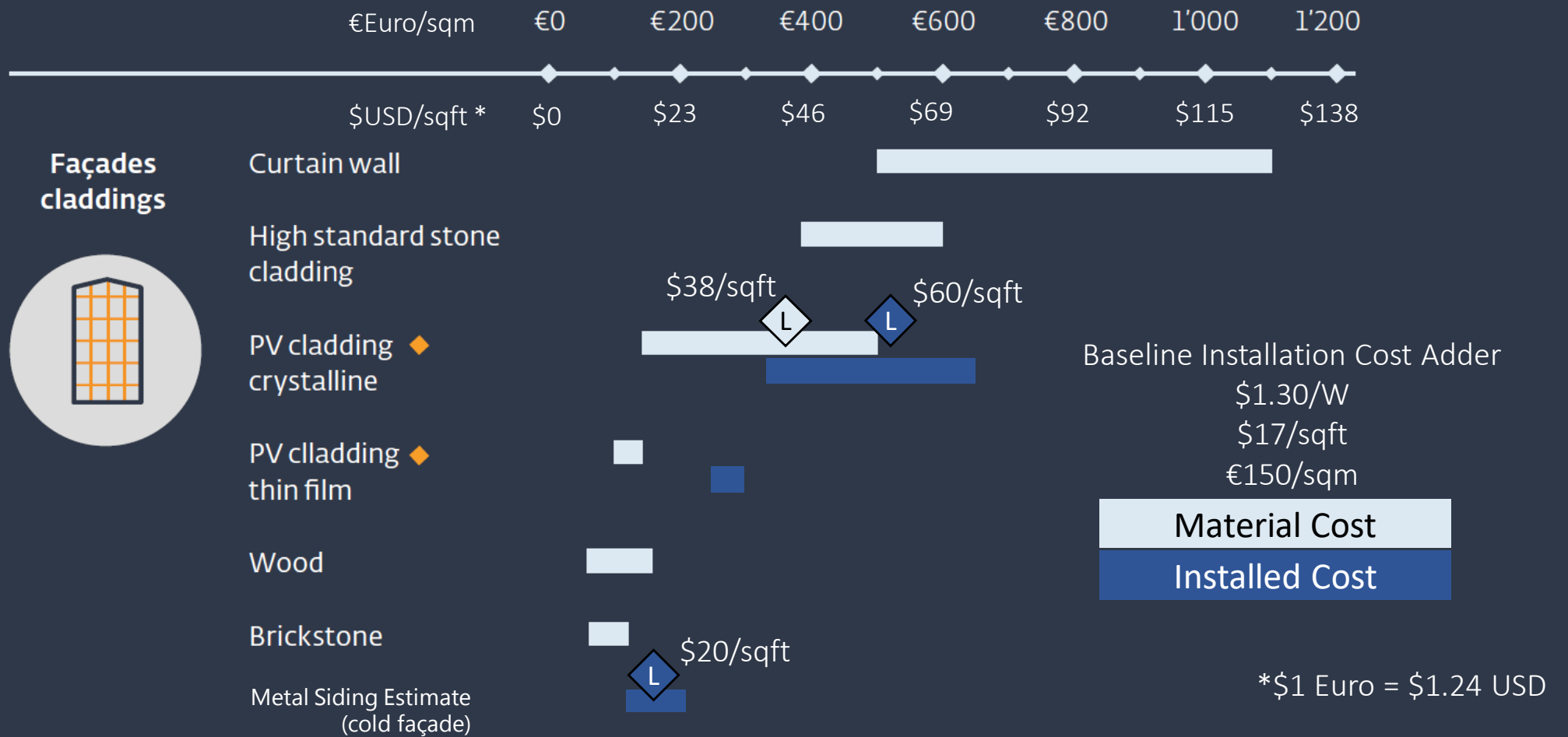
System Area
1560.6 sqft



\$60/sqft

(\$18/sqft)

\$42/sqft



Source: University of Applied Sciences and Arts of Southern Switzerland SUPSI Building Integrated Photovoltaics: Product overview for solar building skins Status Report 2017
Data added by ASA – USD/sqft, Baseline Install Cost, Total Install Cost Metal Wall Cladding Estimate, Case Study Data Points

SUPSI – Material Costs



BIPV Incremental Installed Cost

\$60 /ft² or €521 /m² - Installation Cost

- \$20 /ft² or €174 /m² – Cold Façade Metal Cladding

\$40/ft² or €347 /m² (\$3.01/watt) – Incremental Cost

- \$18/ft² or €157 /m² (\$1.36/watt) – Investment Tax Credit

\$22/ft² or €191/m² (\$1.65/watt) – Post ITC Incremental Cost



\$34,267

Note: Individual lines have been rounded then summed in USD, actual sum may differ



Affordable
Alternative
Energy

SOLAR INSTALLATION BID ESTIMATE

303.665.0006 : info@AAEpower.com : www.aaepower.com : Boulder, Colorado

Savings-Production-Profit

Your current yearly electrical consumption

50,000 KWatt/hrs.

Estimate

Your new solar PV system will annually generate

20,444 KWatt/hrs.

Panels Facing: 135/225

The percentage of demand your new system will produce

41%

Annual Generation savings increases as the utility increases the cost of electricity by at least 6% a year.

REC payment & Generation reduces as the panels age and production decreases. Production Warranty is for 80% in 25 years.

Year	Annual Generation Savings	Annual REC Credit	Annual Depreciation Savings	Cumulative Savings	Pay-Off/ Balance
Based on current electricity charge of 12 cents per Kwatt/hr.					
1	\$2,434	\$1,217	\$3,942	\$7,592	(\$58,106)
2	\$2,559	\$1,207	\$3,942	\$15,300	(\$50,398)
3	\$2,691	\$1,197	\$3,942	\$23,131	(\$42,568)
4	\$2,830	\$1,188	\$3,942	\$31,090	(\$34,609)
5	\$2,975	\$1,178	\$3,942	\$39,186	(\$26,513)
6	\$3,129	\$1,169		\$43,483	(\$22,216)
7	\$3,290	\$1,160		\$47,932	(\$17,766)
8	\$3,459	\$1,150		\$52,542	(\$13,157)
9	\$3,637	\$1,141		\$57,320	(\$8,378)
Pay-Back - 10- years & 8-months					
	\$3,825	\$1,132		\$62,277	(\$3,421)
11	\$4,022	\$1,123		\$67,422	\$1,724
12	\$4,229	\$1,114		\$72,765	\$7,067
13	\$4,447	\$1,105		\$78,317	\$12,619
14	\$4,676	\$1,096		\$84,090	\$18,391
15	\$4,917	\$1,087		\$90,094	\$24,395
16	\$5,170	\$1,079		\$96,343	\$30,644
17	\$5,437	\$1,070		\$102,850	\$37,151
18	\$5,717	\$1,062		\$109,628	\$43,930
19	\$6,011	\$1,053		\$116,693	\$50,994
20	\$6,321	\$1,045		\$124,058	\$58,360
20 year contract with Xcel savings & profit					
	\$81,776	\$22,573	\$19,710	\$124,058	\$58,360

Revised Expense
\$34,267

~4.5 yr payback

The Evolution of BIPV Software



Philippe Alamy

Co-Founder of EnerBIM
&
Program Manager for BIMSolar

The Market Needs BIM + Solar

Architects & Engineers need a comprehensive platform to merge CAD modeling with PV Production & the countless multifunctional benefits of Architectural Solar.



Thank you!

Christopher Klinga P.E.
Technical Director, ASA
Principal, SolMotiv Design

chris@archsolar.org
Architectural Solar Association
PO Box 1574 Boulder, CO 80304

Thank you to the
following companies for
all their great images!



spotlight solar.

