

Integration of Energy Efficiency and Renewables for Maximum Benefit

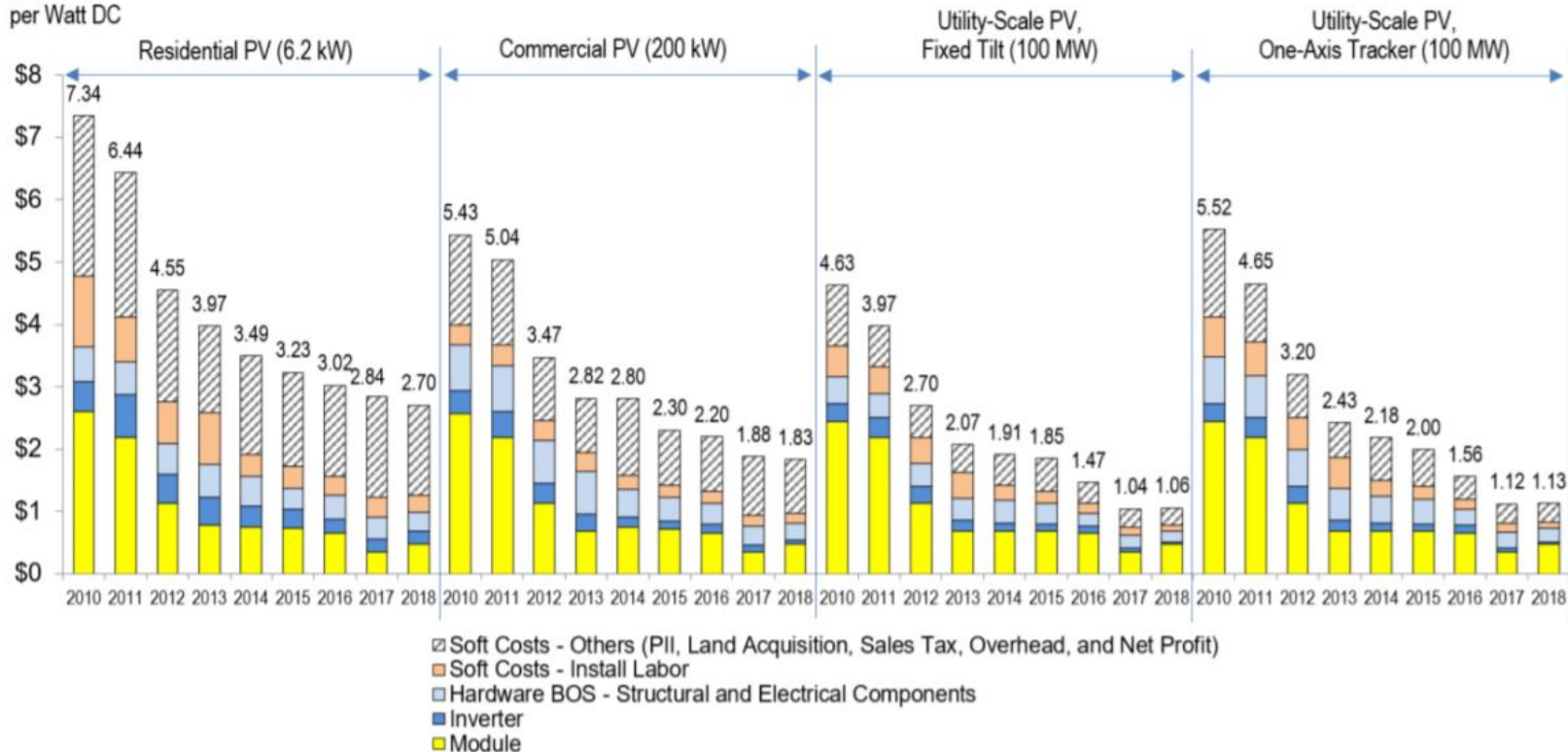
Paul Torcellini, Ph.D., P.E.

Shanti D. Pless

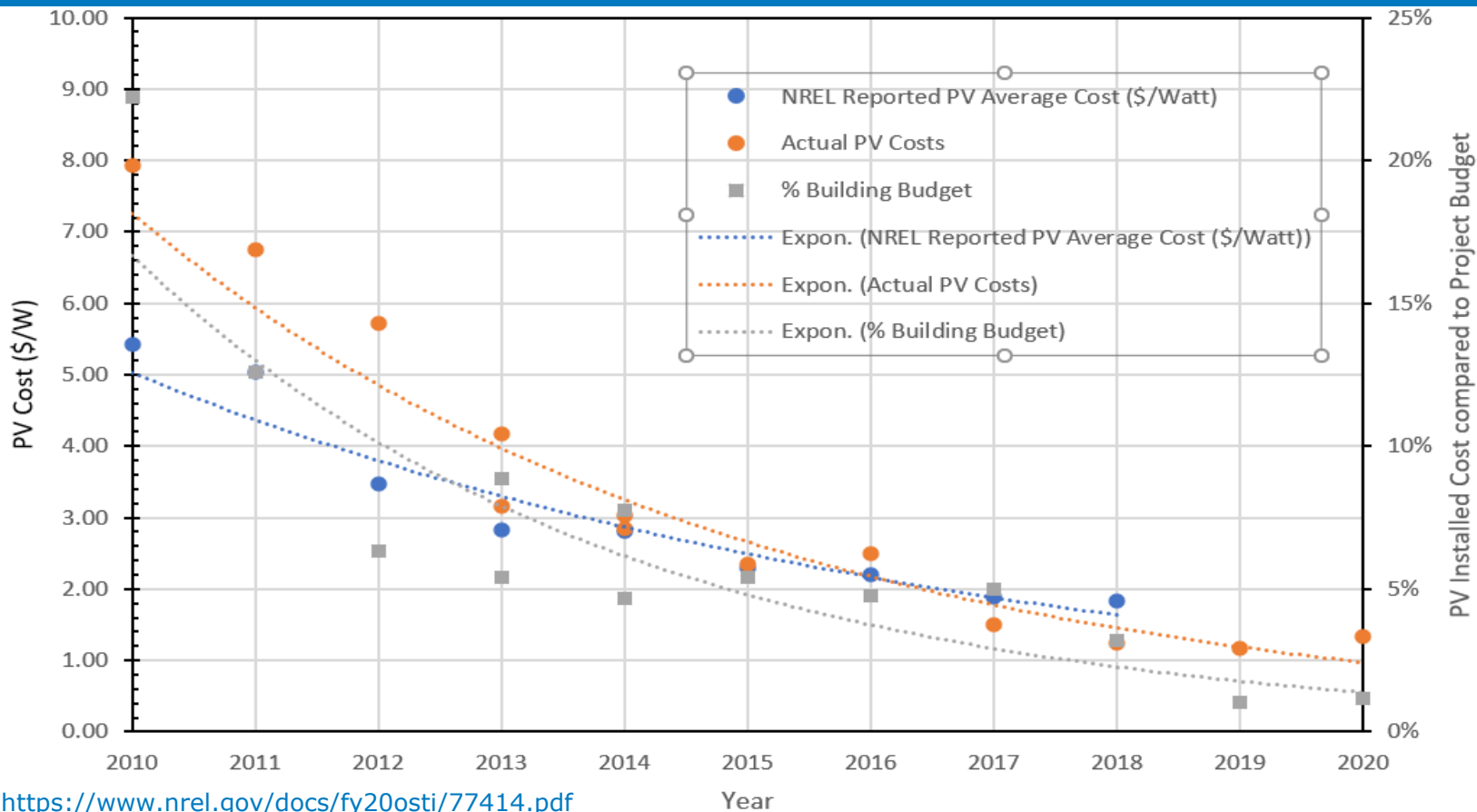
Sixth IEA-Tsinghua Joint Workshop on
Sustainable Recovery in the Buildings Sector

United States 10-Year PV Installed Costs

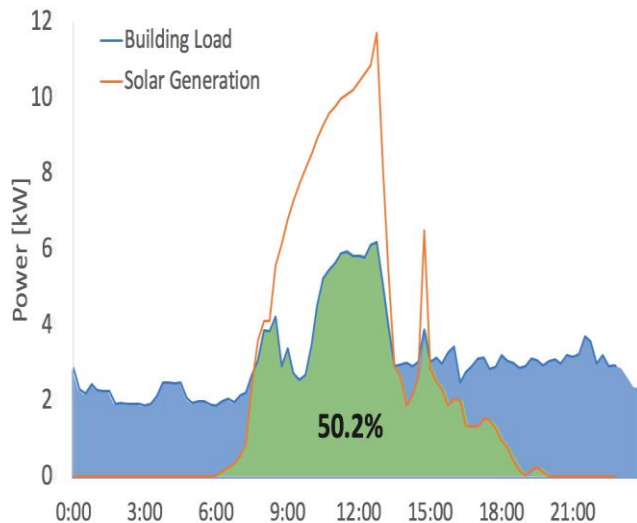
2018 USD
per Watt DC



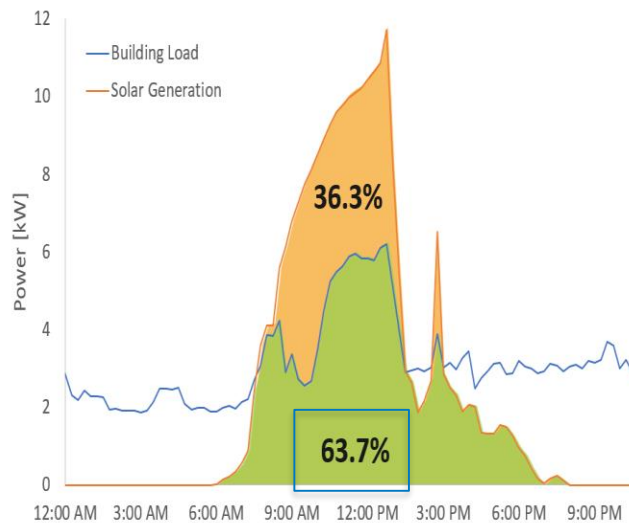
PV Costs Compared to Building Costs (K-12 Schools)



Aligning Renewables with Building and Grid Needs



Load Coverage Factor



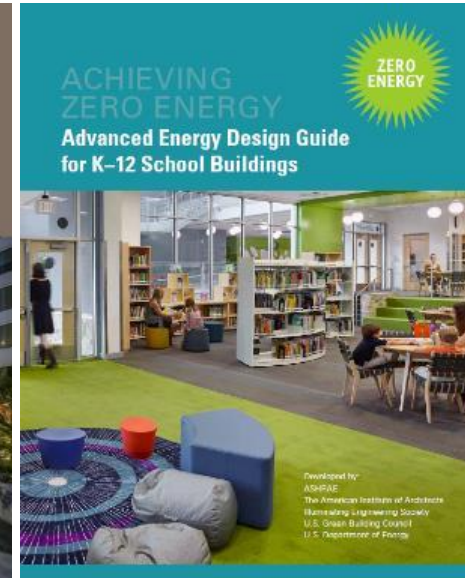
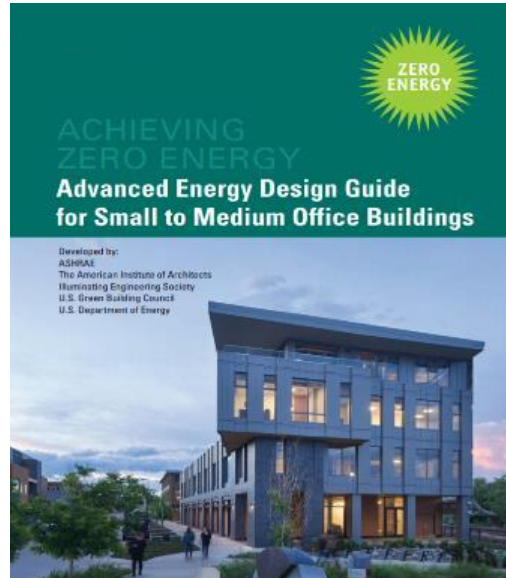
Solar Use Index

Zero Energy Trends

Resources:

Advanced Energy Design Guide for Achieving Zero Energy

- Design guidance by building type and climate zone
 - Supported by case studies and energy modeling
- Developed by leading industry experts
- Looked to for beyond energy code



More information: <https://www.ashrae.org/technical-resources/aedgs>



AIA



NREL CAMPUS



LEED Zero

NREL Research Support Facility

GOLDEN, COLORADO

Has fulfilled the requirements of LEED Zero Energy certification, as verified by Green Business Certification Inc.

LEED Zero, developed by the U.S. Green Building Council, is a complement to LEED that verifies the achievement of net zero goals and signals market leadership.

LEED Zero Energy

FEBRUARY 2020

Michael Ramminger

Michael Ramminger
President & CEO, Green Business Certification, Inc.

NREL

REALIZING HIGH-PERFORMANCE BUILDINGS

How To Maximize Energy Efficient Design, Control, Energy Modeling, Operation

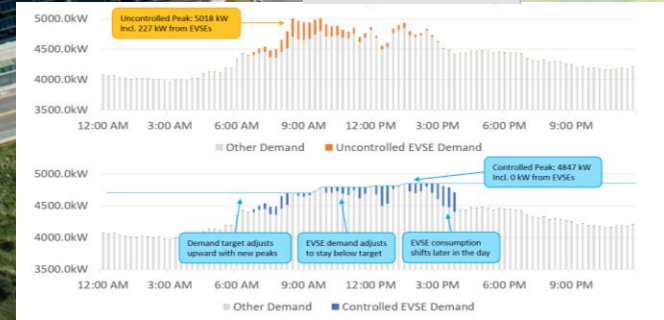
QR CODE SPACE #

Cost Estimate Total Energy 75 kWh

Multi-Have 30 miles

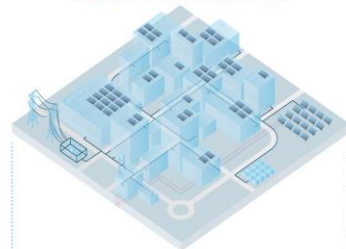
Departure: Tomorrow at 2:50 AM

▲ Entered Destination Time
▲ Estimated Completion Time



National Western Center, Denver CO

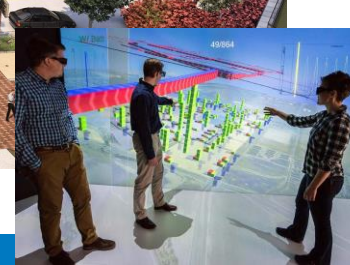
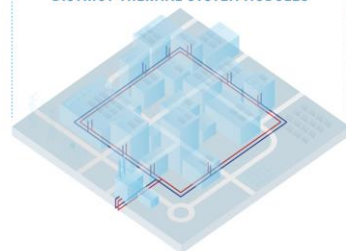
250-acre District Zero Energy with Ambient Loop and Wastewater Heat Recovery



BUILDINGS CORE MODULES



DISTRICT THERMAL SYSTEM MODULES



<https://www.nrel.gov/buildings/urbanopt.html>

NATIONAL RENEWABLE ENERGY LABORATORY

United Therapeutics Unisphere

Net Zero New Construction Goal, Silver Springs, MD

<http://utunisphere.com/>



Taller requires more creative PV integration

South Façade PV in Denver, Colorado produces more than optimal tilt in Northeast United States...

- 1,000 kWh/kW+
- Also provides seasonal balance with winter peak production

Image: Bouldercommons.com



Summary

- In the United States, there is enough commercial building roof area to power those buildings with a 50% energy reduction
- For new construction and major renovation a 40 to 60% energy reduction is possible for zero or little additional cost
- Alignment of building needs with renewable generation is important with important to increase renewable generation
- Energy efficiency is the top priority balanced with renewable generation

Presenters:

Paul Torcellini
Shanti Pless

Thank you

www.nrel.gov

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