City of Philadelphia: Sustainable Energy Finance Strategy and Potential

Revised and Submitted on January 2018

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January, 2018

Meet Our Dedicated Team

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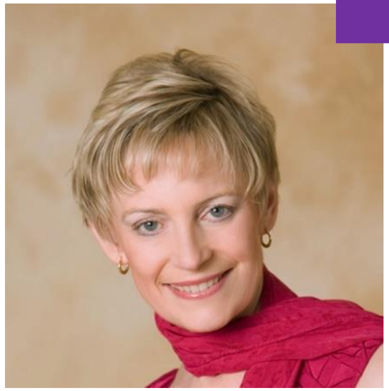


Pam Hague

Program Manager

About FREE

FREE IS A NON-PROFIT, INTERNATIONAL ORGANIZATION ESTABLISHED TO PROMOTE A BETTER FUTURE BASED ON ENERGY, WATER AND MATERIALS CONSERVATION, RENEWABLE ENERGY USE, ENVIRONMENTAL RESILIENCE AND SUSTAINABLE LIVELIHOODS.

RESEARCH
Interdisciplinary, international and innovative energy policy research

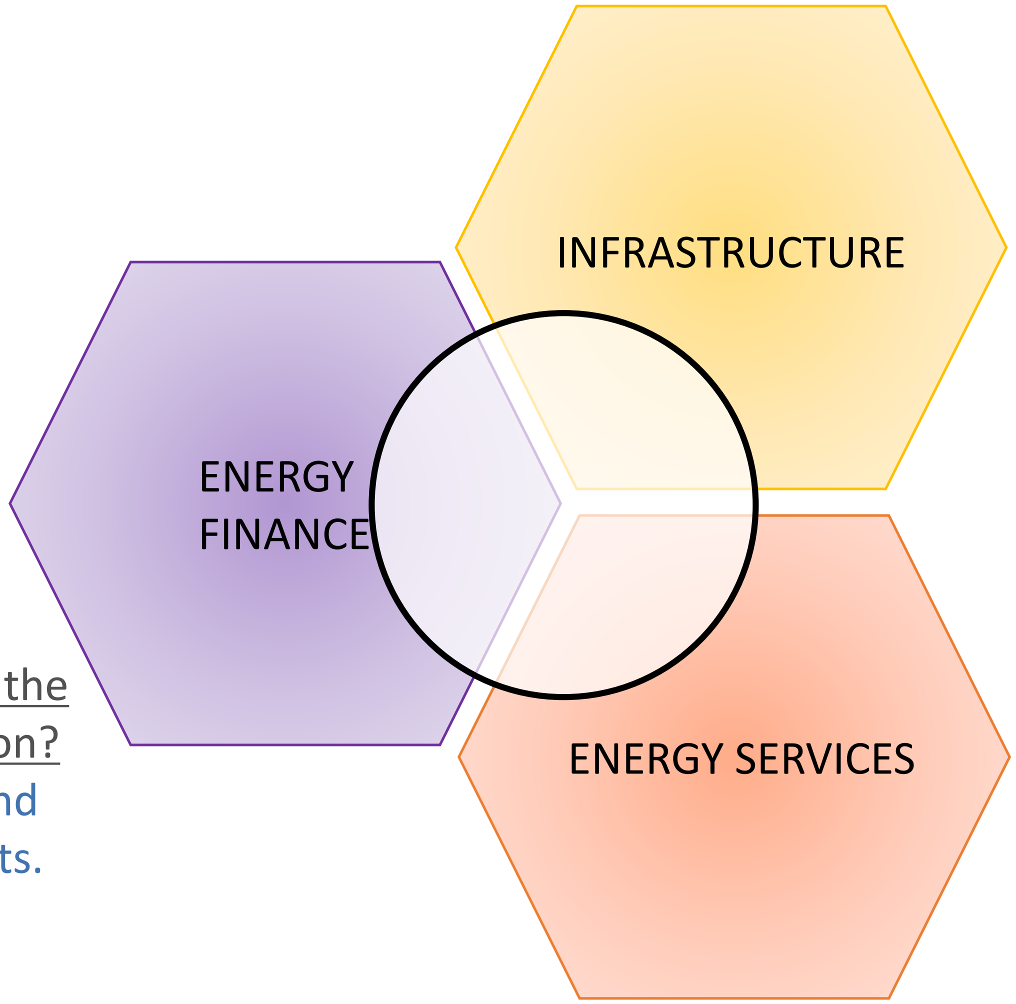
ANALYTICS
Advanced energy, finance & market analysis for project development

FINANCE
Enable transformative applications through innovative financing strategies

TRUSTED ADVISOR
Strong focus on client risk mitigation across all project dimensions

FREE Research on Cities

- How can cities enable sustainability transition at the infrastructure-scale? Answer: Utilize resource-potential at the community-level.



- How can cities afford the sustainability transition? Answer: Pool value and engage capital markets.

- How can cities sustain a high level of energy services while ensuring sustainability? Answer: Deep efficiency investments plus on-site renewable energy.

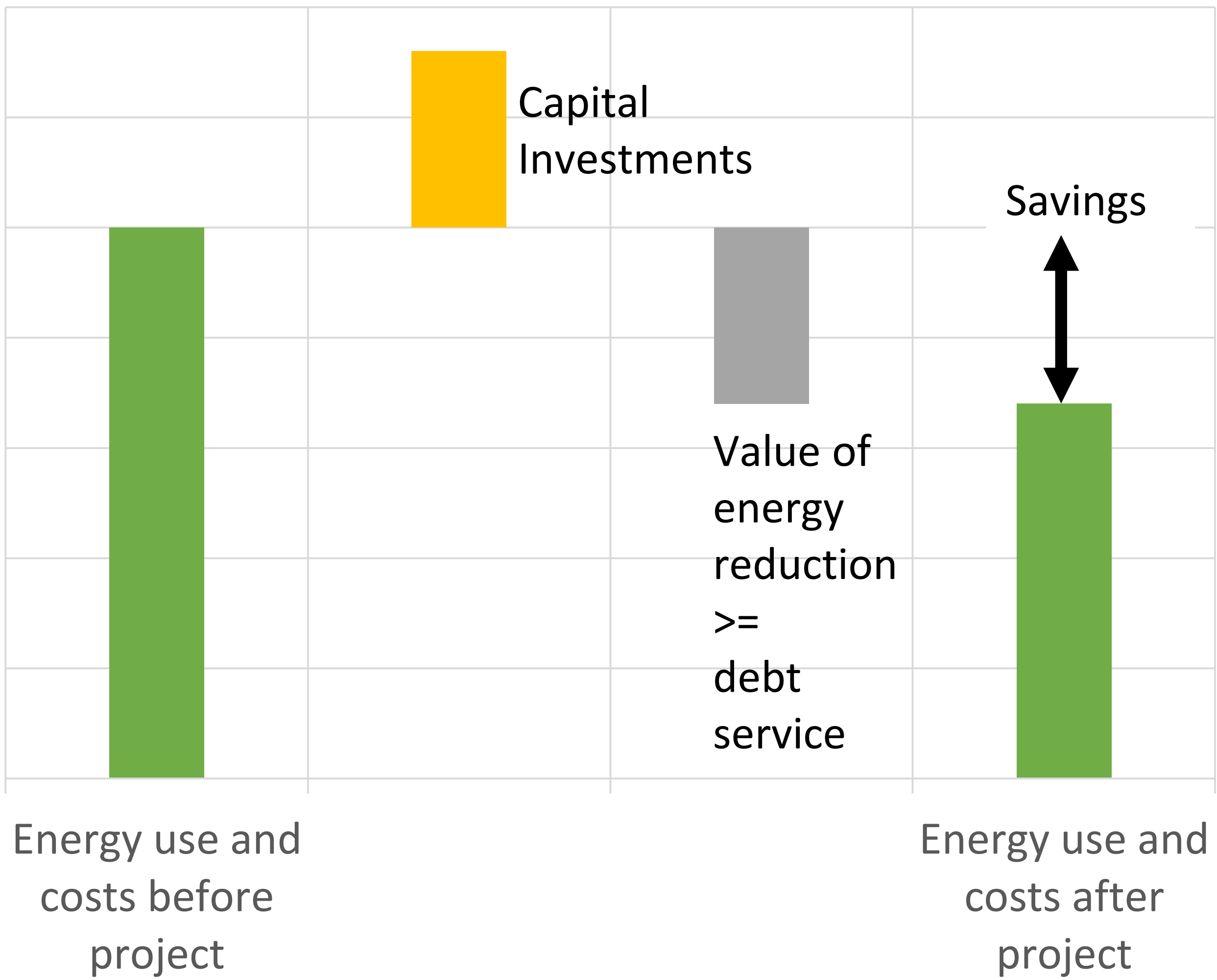
Sustainable Economics: A Self-Financing Energy Strategy

Self-Financing as a Basis for Capitalization

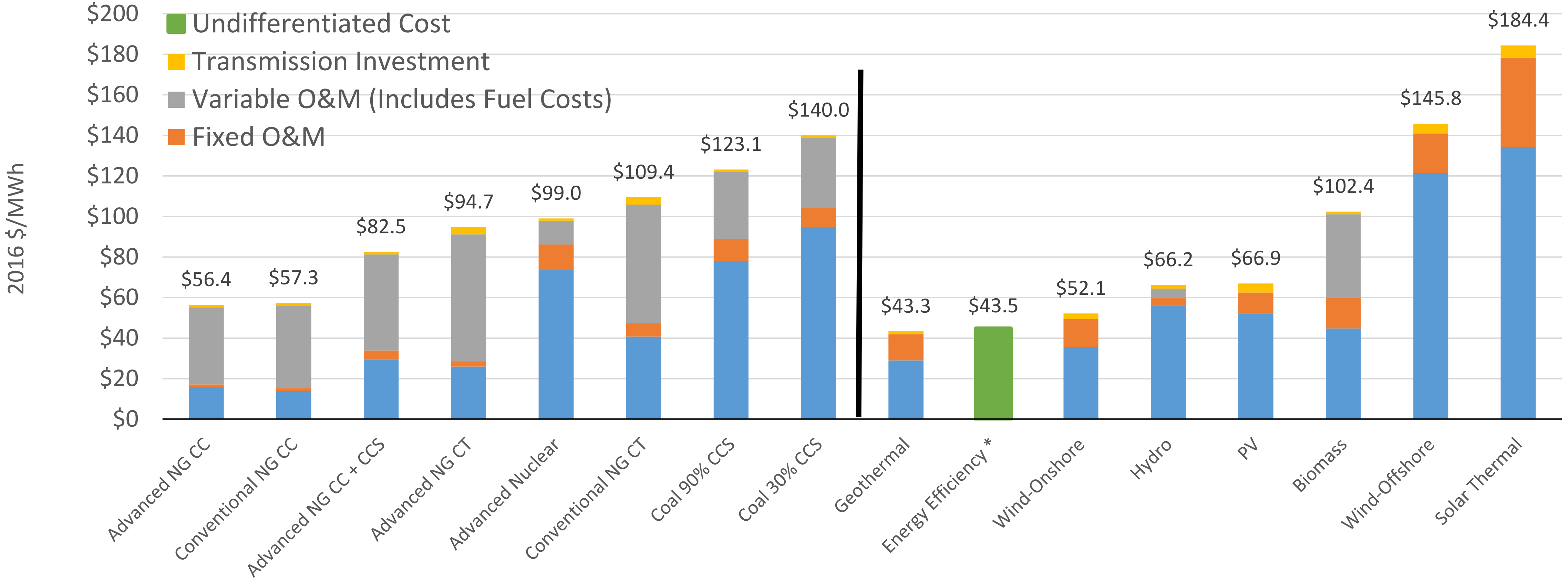
STANDARDIZED CONTRACTUAL ARRANGEMENTS <u>GUARANTEE</u> THAT:
Energy and dollar savings that match or exceed all financing, capital, and program costs

FREE FINANCING STRATEGY OVERCOMES CRITICAL BARRIERS:
- High upfront cost spread out over project lifetime
- No interest cost penalties for small participants
- Technology portfolio approach
- Unlocks deep retrofit opportunities
- Guarantee eliminates uncertainty and reduces risk

POOLED FINANCE AGGREGATES COMMUNITY DEMAND:
- Actionable and financeable projects portfolios
- Attract low-cost capital at scale

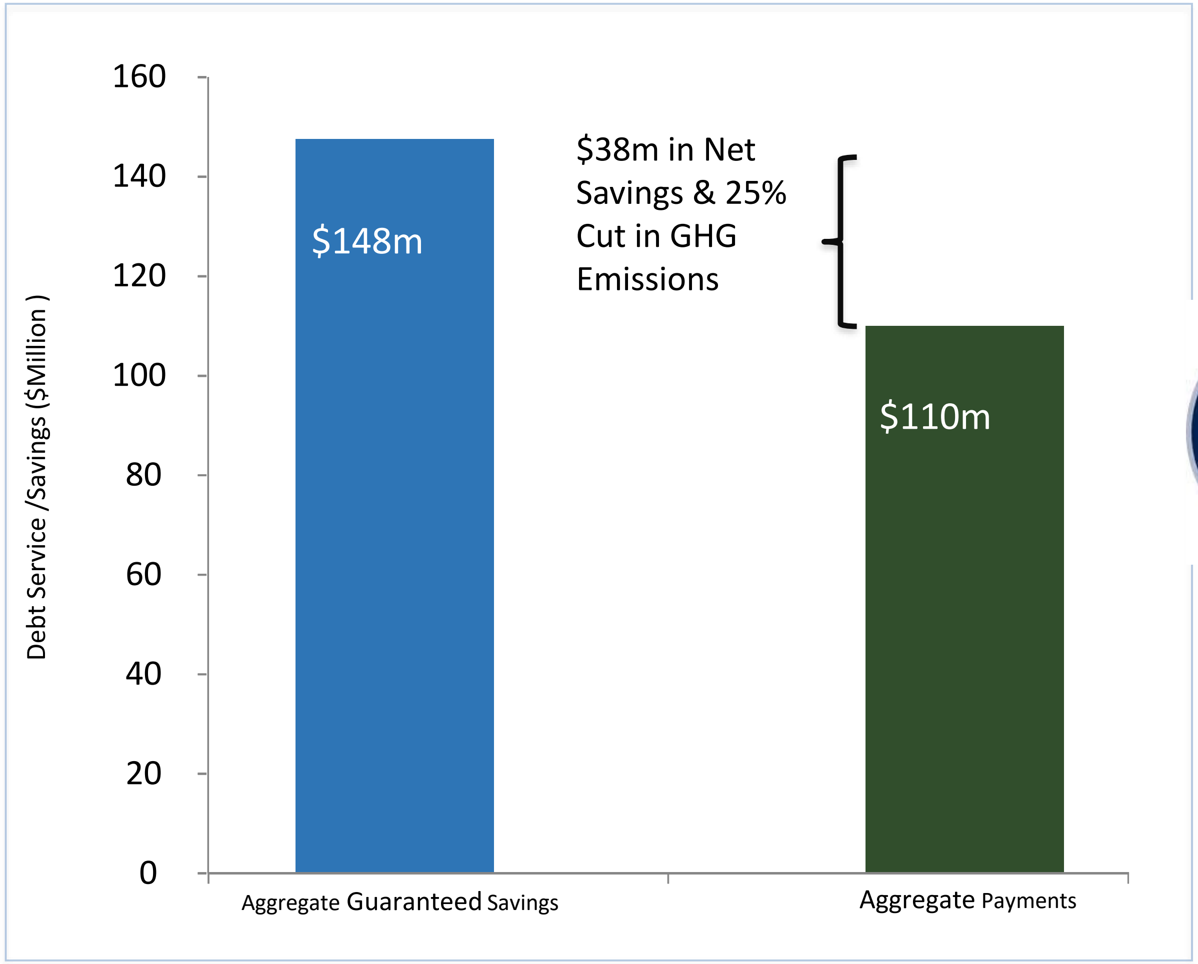


Self-Financing Investment in Sustainability: Energy Efficiency and On-site Renewables



Source: Energy Information Administration (EIA), 2017. Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017. Table 1B. Note: Levelized cost with tax credits reflects tax credits available for plants entering service in 2022. ; Hoffman et al. (2017). Estimating the cost of saving electricity through U.S. utility customer-funded energy efficiency programs, Energy Policy 104: 1-12. doi: 10.1016/j.enpol.2016.12.044. * Weighted average total cost of saved electricity was $0.046/kWh for 20 states in 2009–2013.Energy Efficiency data corrected with a Automatic Energy Efficiency Indicator (AEEI) of 0.75%.

Delaware SEU: Market-Tested

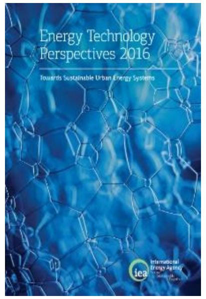


~ 1,000 Jobs

S&P AA+ Rating

JUNE 2011
ASIA CLEAN ENERGY SUMMIT COMMUNIQUE
ASIAN DEVELOPMENT BANK RECOMMENDS USE OF THE SEU MODEL TO THE REGION'S POLICY MAKERS

DECEMBER 2011
U.S. *BETTER BUILDINGS CHALLENGE*
RECOGNIZES THE DELAWARE SEU MODEL FOR ACCOMPLISHMENTS MERITING NATIONAL ATTENTION



MAY 2016
IEA'S *ENERGY TECHNOLOGY PERSPECTIVES 2016*
ENCOURAGES CONSIDERATION OF THE SEU MODEL FOR PLANNING URBAN ENERGY TRANSFORMATIONS

Delaware SEU: Self-Financing Investment in Sustainability

TRANSACTION:	TAX-EXEMPT BOND	RATING	AA+ by S&P
PAR VALUE = $67.45 MIILION		WITH PREMIUMS	= $72.55 MILLION

SERIAL BONDS: maturities from 1 year (borrowing rate = 0.65%) to 20 years (rate = 4.37%)

AVERAGE SIMPLE PAYBACK PERIOD: ~ 14 yrs

SIX STATE PARTICIPANTS	BOND PROCEEDS (incl. Premium)
Department of Children, Youth and Their Families	$ 1.667 million
Department of Correction	$39.699 million
Department of Natural Resources and Environmental Control & Carvel State Office Building	$ 6.205 million
Legislative Hall, State of Delaware	$ 5.199 million
State Courthouse	$ 1.012 million

TWO HIGHER EDUCATION INSTITUTIONS	
Delaware State University	$12.108 million
Delaware Technical and Community College (3 campuses)	$ 6.661 million

Contracting Companies: Ameresco, Honeywell, Johnson Controls, Noresco, Pepco Energy Services, Trane

MAJOR BUYERS: Definitive Capital, Lord Abbott, First New York Securities, Merrill Lynch

PennSEF
LED Lighting Project

Participating municipalities

BROAD PARTICIPATION

35 PARTICIPATING MUNICIPALITIES ACROSS 4 PENNSYLVANIA COUNTIES

LARGE-SCALE PROJECT

TOTAL PROJECT COST: $14,922,544

RETROFIT > 28,000 STREET AND EXTERIOR LIGHTS

- ABOUT 370 MILES OF ROAD LIGHTED *

DEEP AND SIGNIFICANT ENERGY AND FINANCIAL SAVINGS

GROSS SAVINGS: $30,586,648

NET SAVINGS: $15,633,874

AVERAGE PAYBACK: 10.64 YEARS

- Estimate based on average distance between streetlights of 125 ft. - 150 ft. Streetlights are placed opposite each other. Data source: Pennsylvania Spatial Data Access (http://www.pasda.psu.edu/)

PennSEF Triple Bottom Line is met with LED Lighting Project

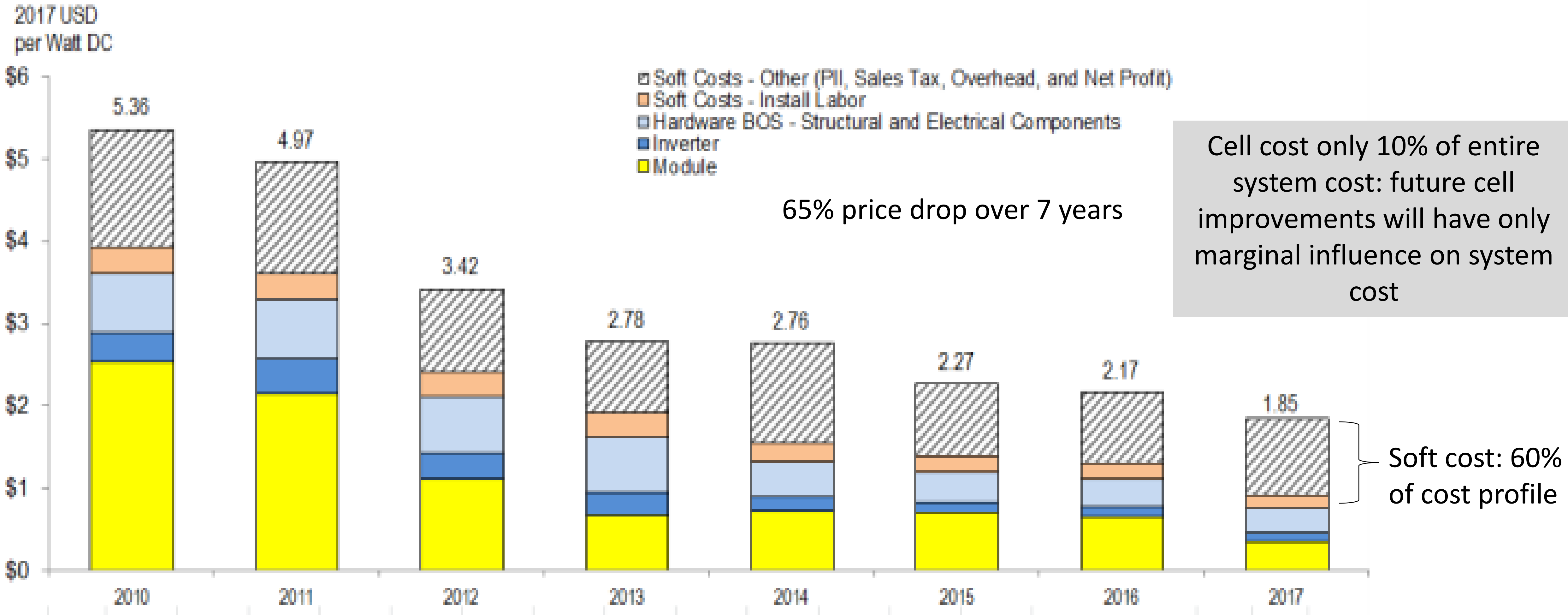
- Reduces cost of government annually for 20 years through guaranteed savings of 40-60% in lighting energy use. [Guarantee provided by Johnson Controls, Inc.]

- Creates jobs and adds value to the local economy. The project has created the equivalent of 80 direct, full-time jobs and is resulting in more than $15 million in net savings to the local economy after all costs of the investment are deducted.

- Lowers the municipalities' environmental footprint by cutting greenhouse gas emissions up to 150 thousand tons, an amount equal to the avoided emissions for 20 years of operation of a 7 MW_p solar power plant.

City-wide Solar PV Deployment Opportunities in Philadelphia

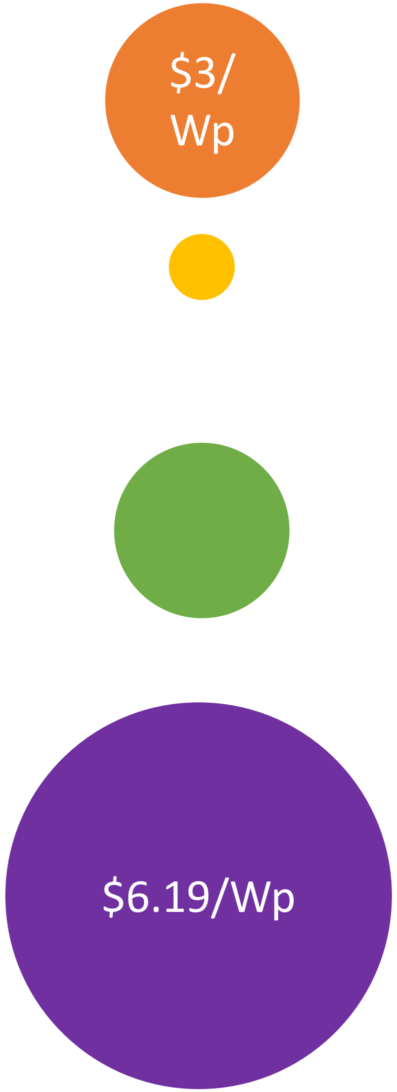
PV Technology – Changing Economics



Cell cost only 10% of entire system cost: future cell improvements will have only marginal influence on system cost

Courtesy of Steven Hegedus, Institute of Energy Conversion, University of Delaware.
NREL Commercial PV System Cost Benchmark Summary 2010-2017, 200 kW system
Source: Fu et al. (2017). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. National Renewable Energy Laboratory

PV Technology – Local Economic Impact



German Residential System Cost ($3/Wp)

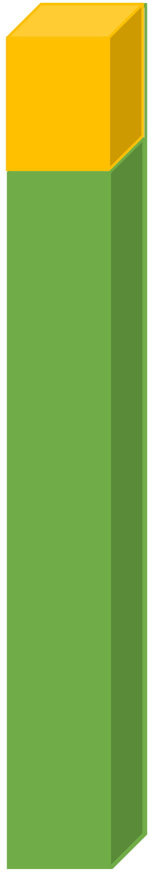
Difference:"Hard" Costs ($0.47/Wp)

- Module ($0.01)
- Inverter ($0.22)
- Other ($0.24)

Difference: "Soft" Costs ($2.72/Wp)

- Installation Labor ($0.36)
- Search Costs ($0.62)
- PII ($0.12)
- Permitting Fee ($0.09)
- Other ($1.53)

U.S. Residential System Cost ($6.19/Wp)



MANUFACTURING & HARDWARE

9% of the gross value added

~15% of the jobs

INSTALLATION AND SOFT COSTS

91% of the gross value added

~85% of the jobs

Seel et al. (2014). An analysis of residential PV system price differences between the United States and Germany, Energy Policy, Volume 69: 216-226, Numbers in 2011$

Solar Foundation (2015). National solar job census 2015. Available at tsfcensus.org. Solar Power Europe (2015). Solar photovoltaic jobs and value added in Europe.

FREE Solar City Research Approach

Module 1: PV Rooftop Technical Potential

Building-Based Data (e.g. LiDAR)

Deductions for shading, maintenance, etc.

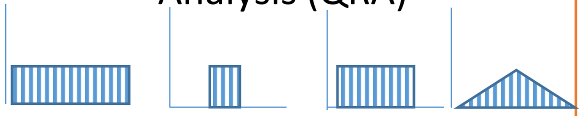
System Design & Location Specifics

Rooftop Suitability Estimate

Module 2: Financial Assessment

Market Conditions (PV Pricing, etc.)

Quantitative Risk Analysis (QRA)

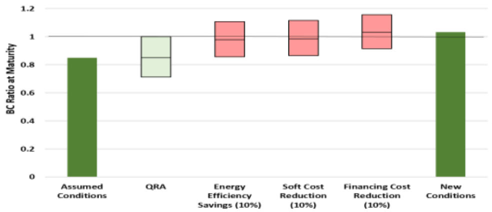


Financial Feasibility of Rooftop Power Plant

Module 3: Policy Assessment

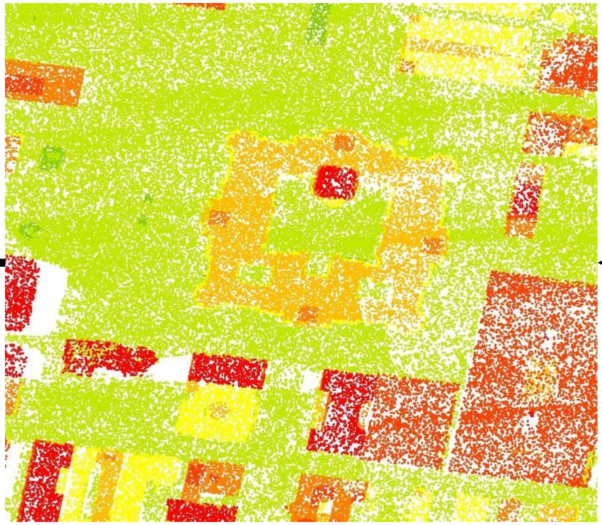
Policy Strategies and Scenarios

Scenario Analysis to Find Successful Policy Strategy



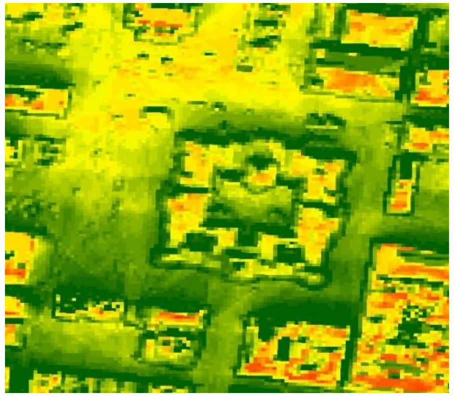
Practical Feasibility of Rooftop Power Plant

Module 1: Technical Potential

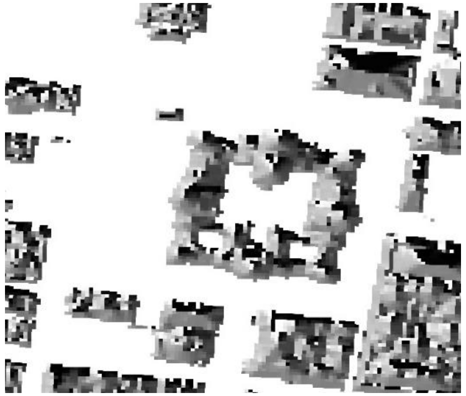


Question:

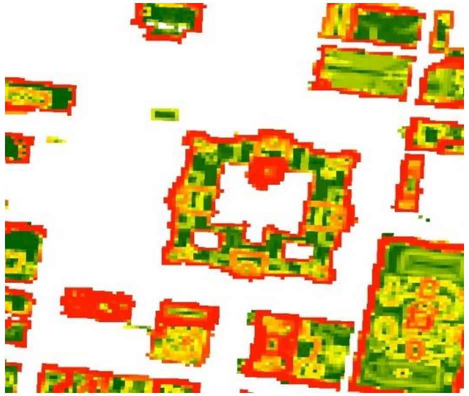
How much rooftop space is available for PV?



SHADING



ASPECT

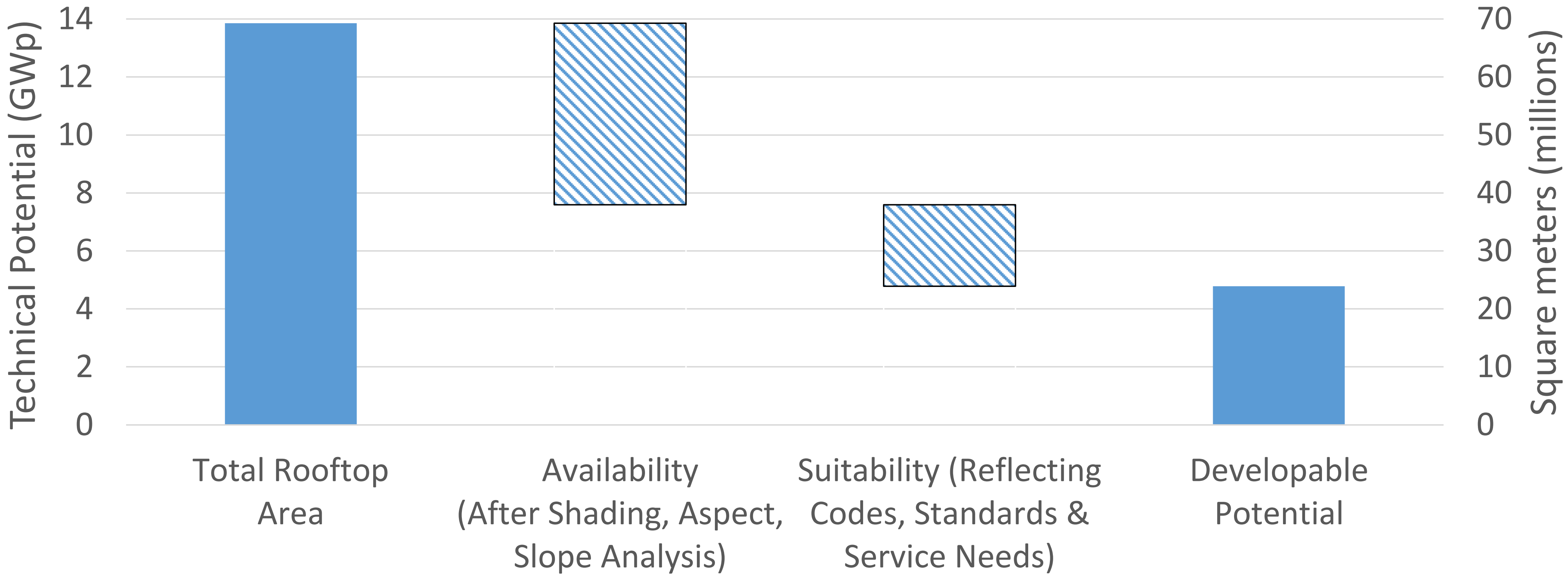


SLOPE

Module 1: Key Technical Assumptions

Input parameter	Value	Source:
Module Power Density	200 W/m2, equal to a 20% efficient module	Green et al. (2017). Solar cell efficiency tables (version 50). Prog Photovolt Res Appl. 25:668–676. https://doi.org/10.1002/pip.2909
Availability: - Rooftop Azimuths - Slope Deduction - Contiguous Space - Shading	- East-to-South-to-West - Only rooftops <60 degrees - Minimum of 10 sq. meters - Threshold number of sunlight hours needed to generate at least 80% of an unshaded system	Robert Margolis et al 2017 Environ. Res. Lett. 12 074013. doi: 10.1088/1748-9326/aa7225
Suitability (reflecting codes, standards, and service needs)	0.63	Byrne et al. (2015). A review of the solar city concept and methods to assess rooftop solar electric potential, with an illustrative application to the city of Seoul. Renewable and Sustainable Energy Reviews: 41, 830-844. doi: 10.1016/j.rser.2014.08.023
System Tilt	Flat roofs: 15 degrees	

Philadelphia Solar City Results: City-Wide Assessment ~ 4.7 GWp

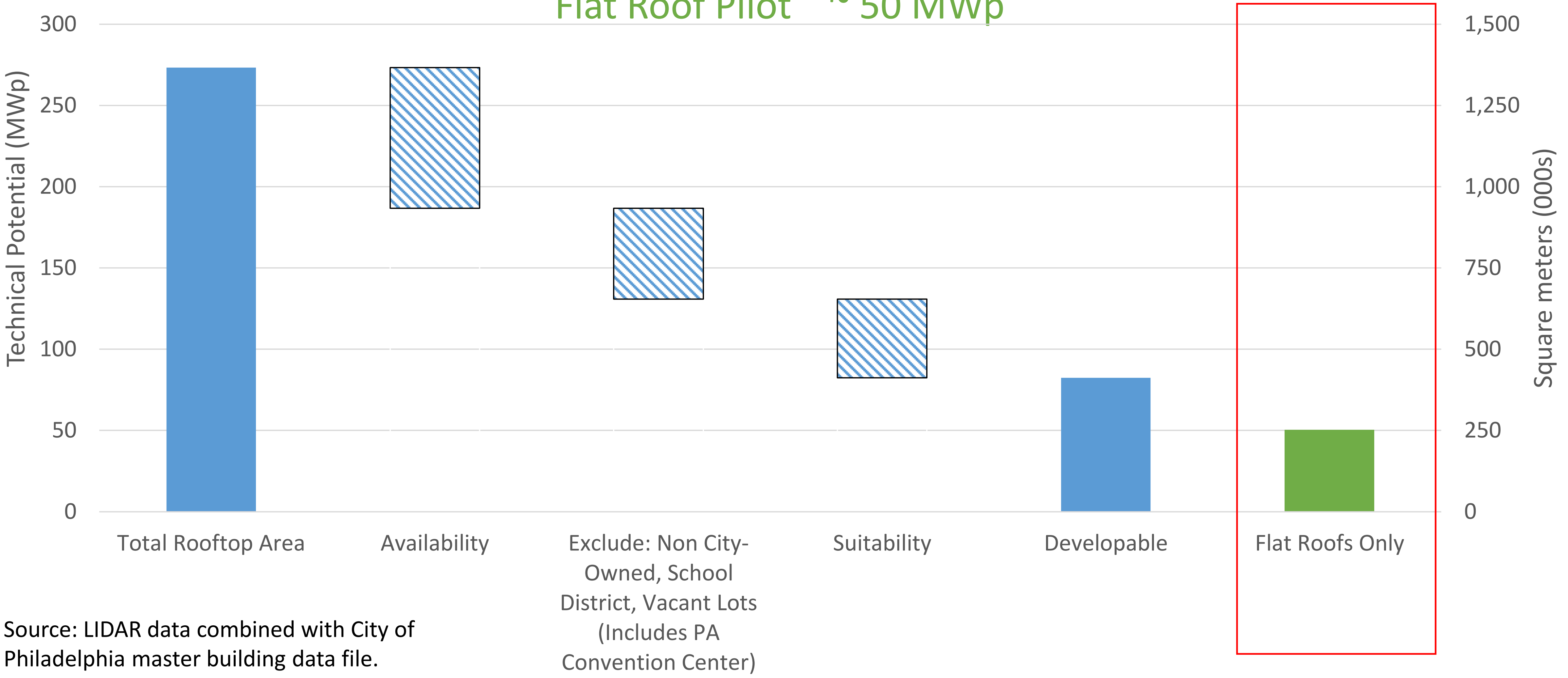


Calculations from LIDAR point cloud data covering the City of Philadelphia, PA. The data was collected at a nominal point spacing of 0.70m using Pictometry's Riegl LMS-Q680i LiDAR system over 4 mission days on April 18th, 19th, 22nd, and 25th, 2015. A total of 1.6 billion first-return data points were used for the analysis. At the time of capture ground condiitons were leaf-off, snow free, and water was at normal levels. Data obtained from: ftp://ftp.pasda.psu.edu/pub/pasda/phillyLiDAR/LAS2015/

Philadelphia Solar City Results:

Public Buildings ~ 82 MWp

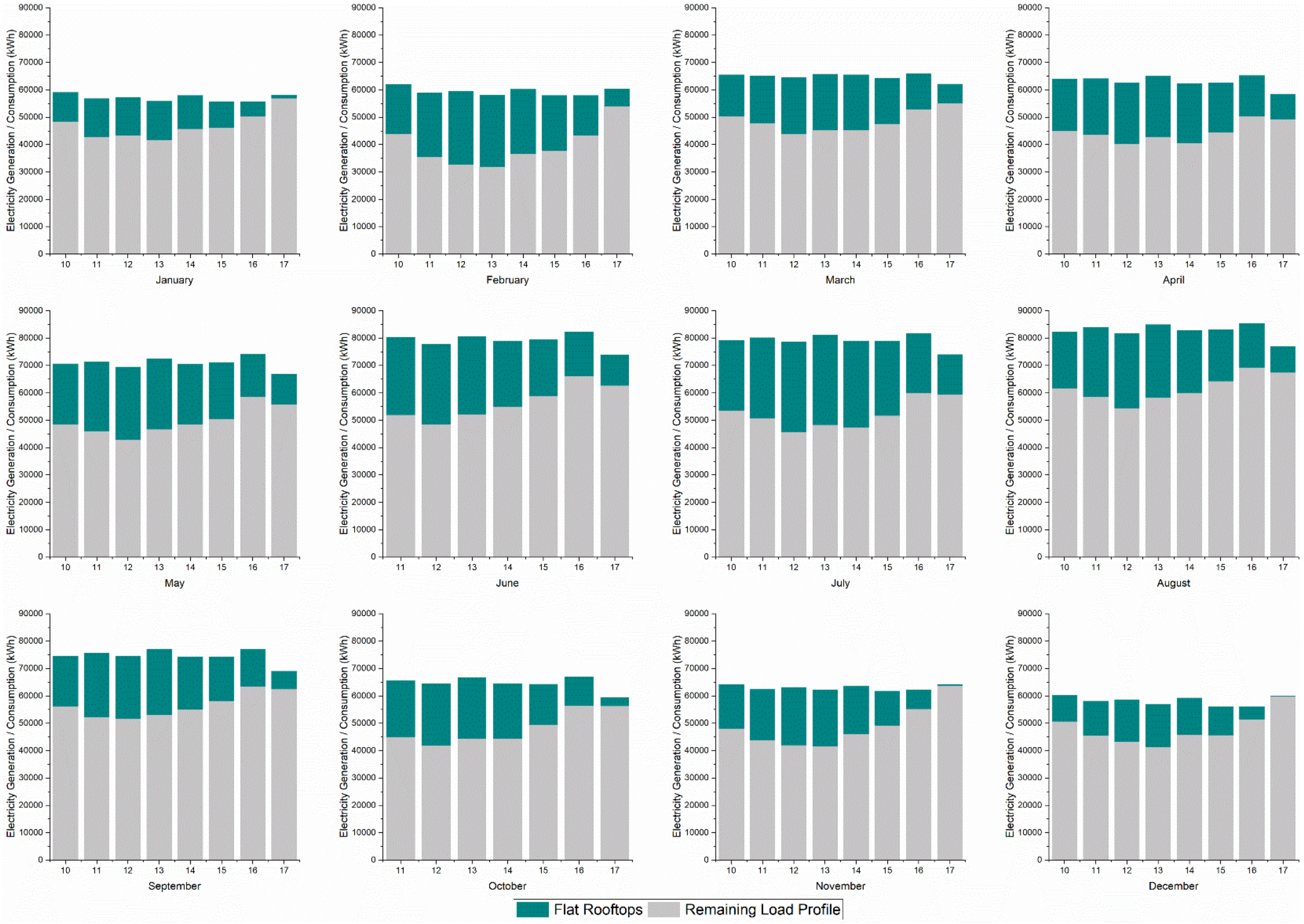
Flat Roof Pilot ~ 50 MWp



Source: LIDAR data combined with City of Philadelphia master building data file.

Module 1: Philadelphia Load Impact Analysis

Illustrated: Daylight-Hour Electricity Consumption and Solar Electricity Generation



FLAT ROOFTOP SPACE:

~251,000 Sq. Meters (61%)

~50.3 MWp

Annual generation: 63.7 GWh

DAYLIGHT HOUR CONTRIBUTION:

January: 16%

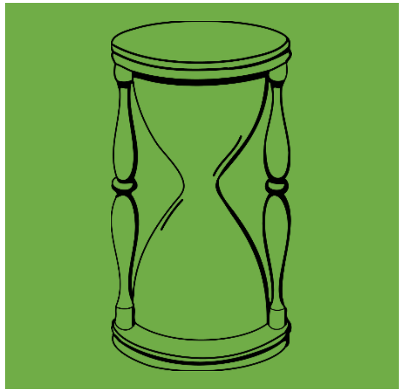
July: 32%

Annual: 24%

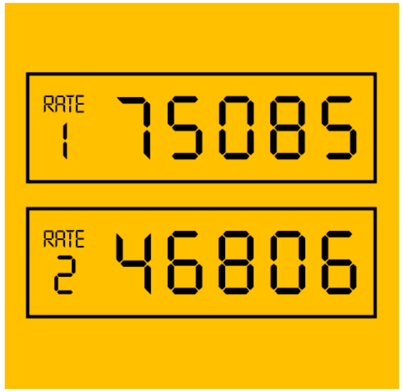
Source: Load curve from DOE Energy Plus scaled to align with Philadelphia annual and peak consumption

Module 2: Financial Assessment

Pooled Finance



Variation in financing cost & duration



Retail rate as basis for compensation

Policy incentives

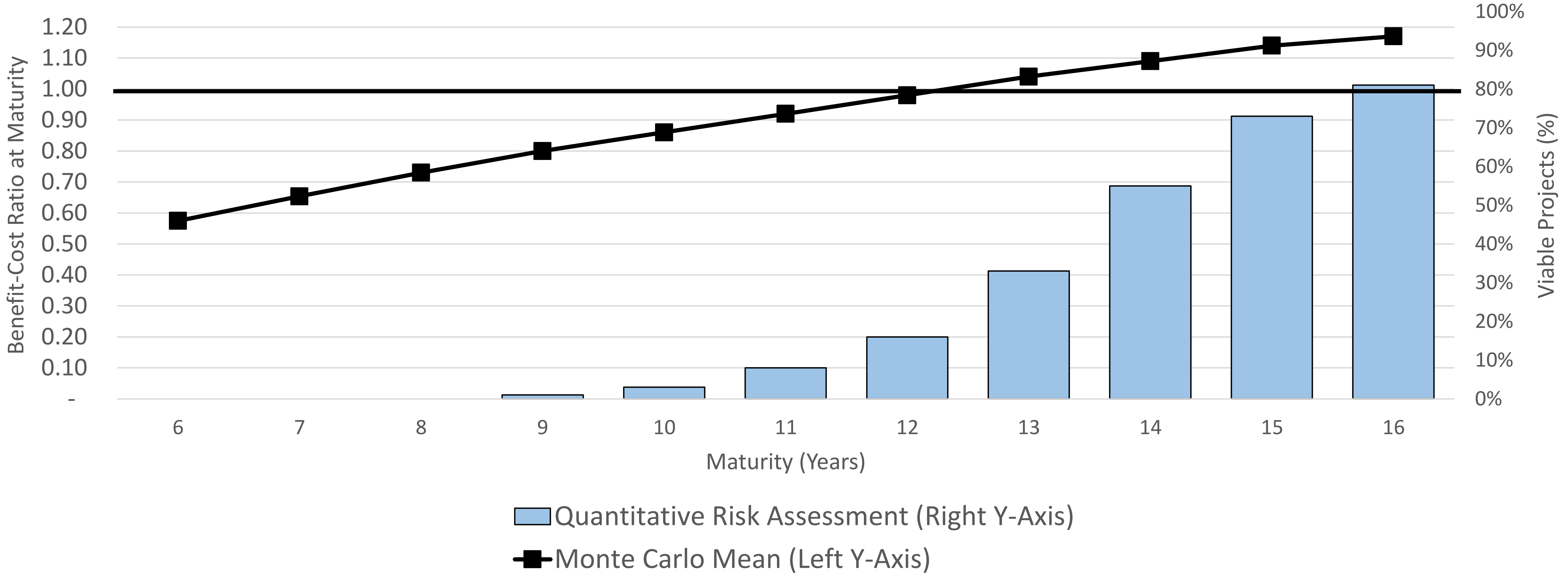
Quantitative Risk Analysis

Module 2: Key Financial Assumptions

Input parameter	Value	Source:
PV System Cost	\$1.85/Wp	Fu et al. (2017). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. National Renewable Energy Laboratory
Cost of capital	5-year maturity: 1.33% 10-year maturity: 2.16% 15-year maturity: 2.72% 20-year maturity: 3.42%	Electronic Municipal Market Access (EMMA), City of Philadelphia 2017 Bond Issues
Effective Electricity Price	Municipal electricity expenditure and consumption: ~\$32 million/year for 291.7 GWH Equivalent to 10.97 cents/kWh	City of Philadelphia (2017). Municipal Energy Master Plan for the Built Environment. City of Philadelphia (2015). 2013 Municipal Greenhouse Gas Inventory.
Policy Incentives	SREC price: \$5/MWh (\$0.005/kWh)	SRECtrade.com DSIREusa.com

MODULE 2: Financial Assessment

Includes risk factors for ~ $93 million PV investment



Source: Electronic Municipal Market Access (EMMA) database; Fu et al. (2017). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017; Byrne et al. 2017. Multivariate analysis of solar city economics: impact of energy prices, policy, finance, and cost on urban photovoltaic power plant implementation. *Wiley Interdisciplinary Reviews, Energy and Environment.* doi: 10.1002/wene.241.

Module 3: Policy Assessment & Development

Improved Building Energy Efficiency

Soft Cost Reduction

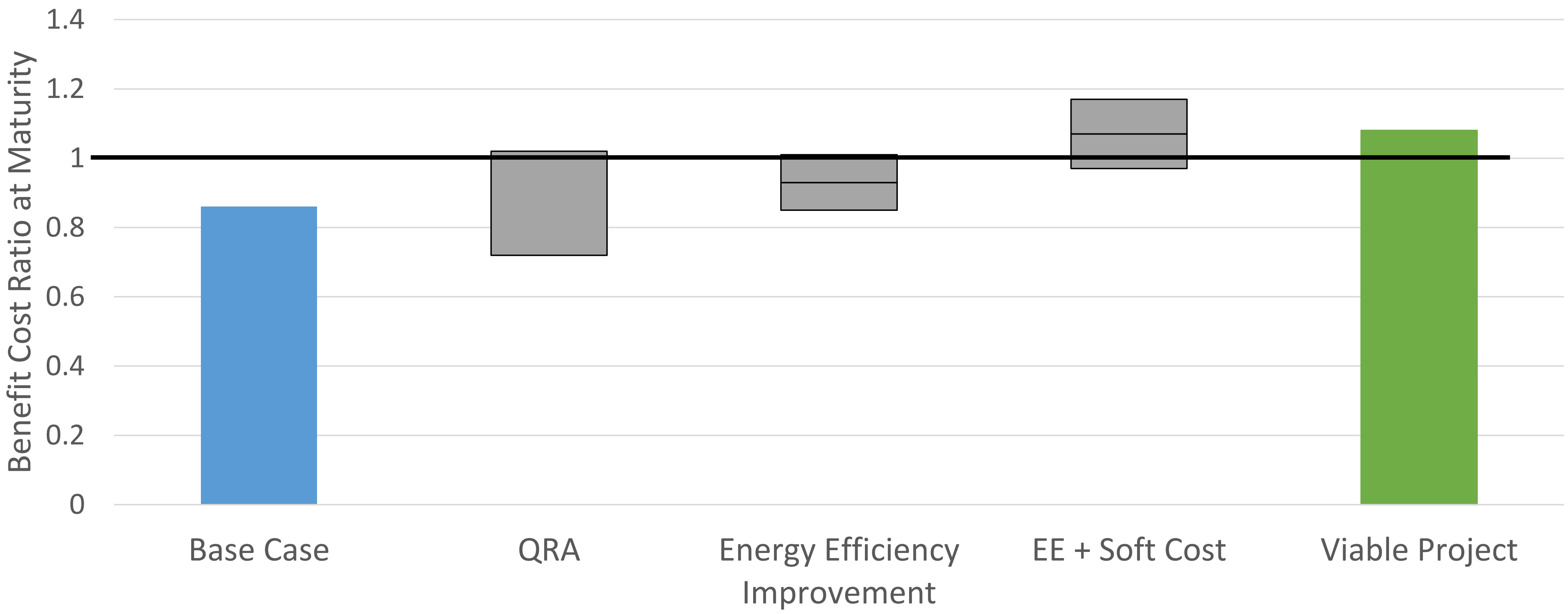
Scenario Analysis

Module 3: Key Assumptions

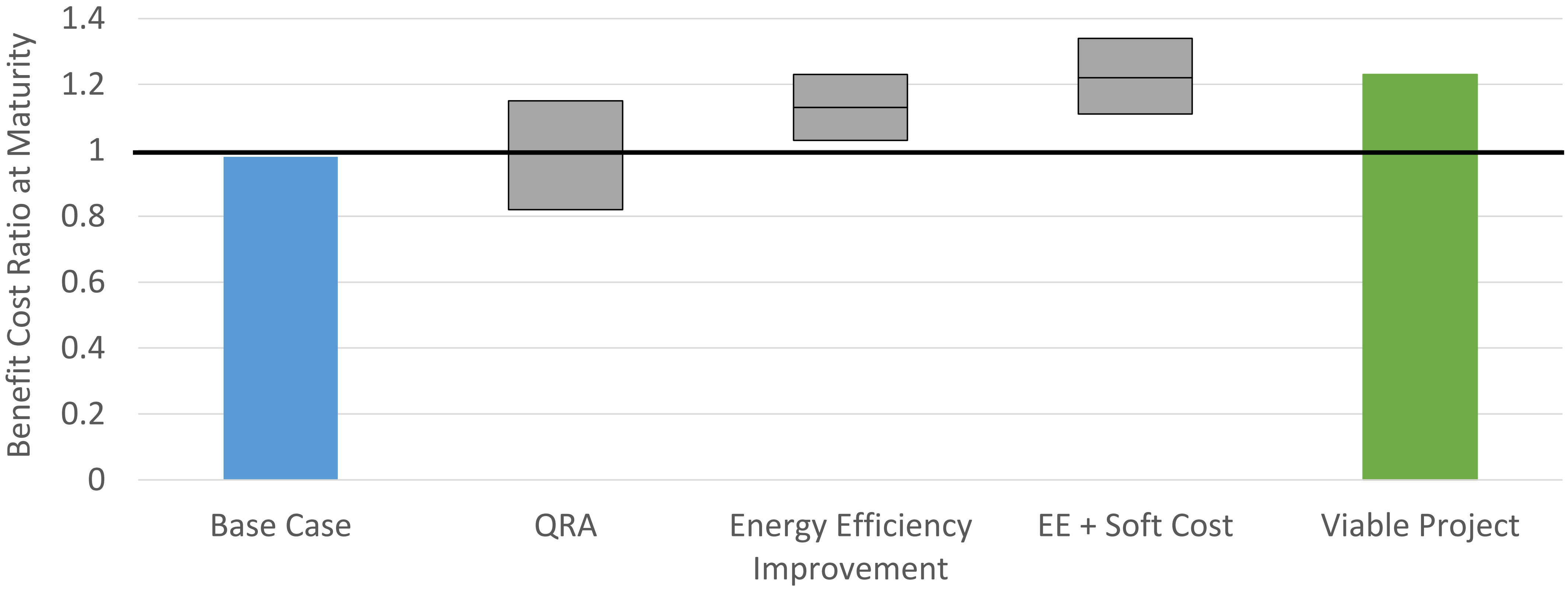
Scenario	Strategy Options	New input	Example
Include cost-effective energy efficiency measures	Establish a portfolio of measures – lower cost energy efficiency can enable higher cost technology like solar PV	Add 10-year payback energy efficiency measures (consistent with a 20% reduction in energy use)	PennSEF, Delaware SEU
Lower PV System "Soft Cost"	Improved standardization, online permitting, improved transparency, customer acquisition streamlining.	Improves soft cost profile by 30% (after invention, soft cost = $0.77, while hard cost = $0.75)*	Germany's soft cost profile 50% lower than U.S. average soft cost (soft cost = $0.059 and hard cost = $0.71)

* Current US costs are: soft cost = $1.10; hard cost = $0.75. See: Source: Fu et al. (2017). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. National Renewable Energy Laboratory; and Fraunhofer (2017) Photovoltaics Report 2017. Comparison is based on 200 kW system.

MODULE 3: FREE Policy and Market Analysis 10-year maturity



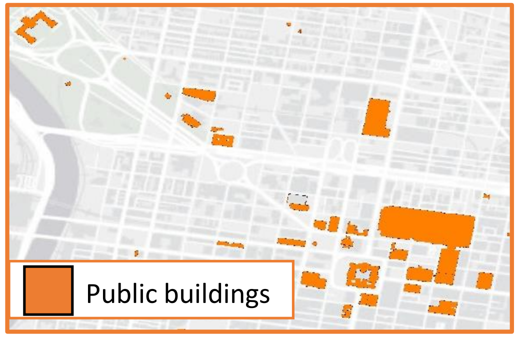
MODULE 3: FREE Policy and Market Analysis 12-year maturity

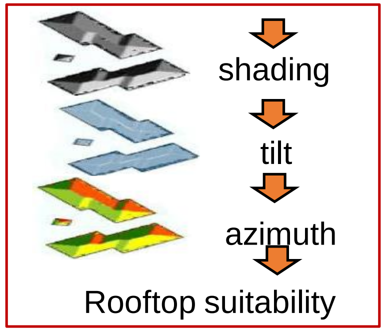


FREE's *Solar Cities* Modeling: Philadelphia's Public Buildings Pilot
(Flat Roofs only)

1

~50 MWp
~251,000 m^2
Investment size: $93 million
617 Buildings Involved in the Pilot





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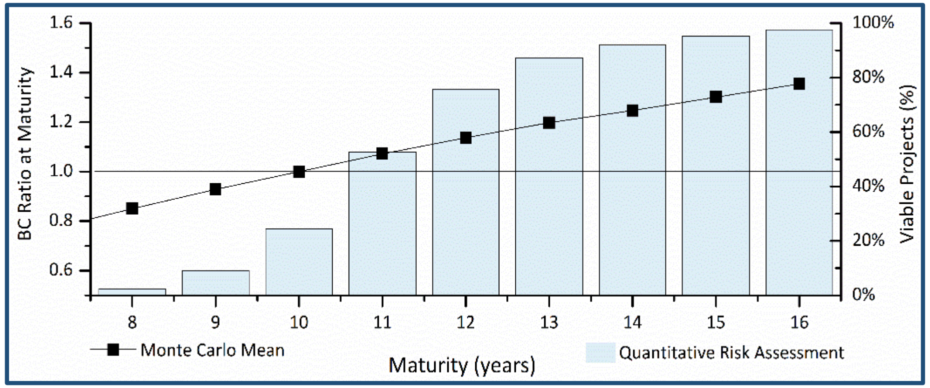
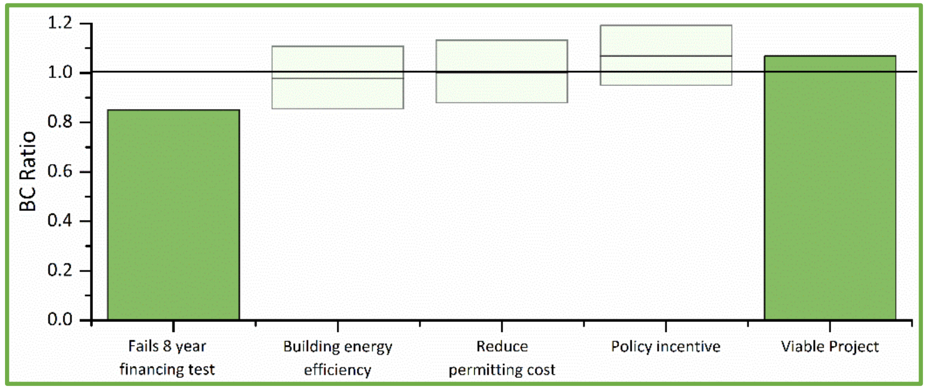
Quantitative Risk Assessment: Financing viable under variable risk conditions



3

Policy Upgrades can realize 10-12 yr. financing



THANK YOU