EBC
Energy in Buildings and Communities Programme

Business and Technical Concepts of Deep Energy Retrofit of Public Buildings IEA EBC Annex 61

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Introduction

- Governments worldwide are setting more stringent targets for energy use reductions in their building stocks
- To achieve these goals, there must be a significant increase in both the annual rates of building stock refurbishment and energy use reduction, for each project (EU: refurbishment rate of 3% p.a., USA: 3% p.a. site energy reduction compared to CBECS 2003 through 2015 and 2.5% between 2015 and 2025)

EU Energy Performance of Buildings Directive (EPBD 2010)

- Member States shall develop policies and take measures such as setting targets to stimulate the transformation of buildings to be refurbished to a nearly zero-energy condition.
- A Member State shall not be required to set minimum energy performance requirements that are not cost-effective over a building's estimated economic lifecycle.
- A nearly zero-energy building is defined as "*a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.*"
- The term "high performance building" (as used in Austria, Germany, the Czech Republic, and Denmark) was developed by the Passivhaus Institute (PHI) for the German building market, and has the same definition as "nearly zero-energy."

IEA-EBC Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings

Annex 61

EBC
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Deep Energy Retrofit (IT-Tool)

Objectives

- To provide a framework and selected tools and guidelines to significantly reduce energy use (by more than 50%) in government and *public buildings and building communities undergoing renovation*
- To gather, research, develop, and demonstrate *innovative and highly effective bundled packages of ECMs* for selected building types and climatic conditions
- To develop and demonstrate *innovative, highly resource-efficient business models for retrofitting/refurbishing buildings and community systems* using appropriate combinations of public and private funding
- To support decision makers in *evaluating the efficiency, risks, financial attractiveness, and contractual and tendering options* conforming to existing national legal frameworks
- To *engage end users, mainly building owners and other market partners*, in the proceedings and work of the Annex Subtasks.

Receptors

- Executive decision-makers and energy managers of public and governmental administrations
- ESCOs
- Financing industries
- Energy utility companies
- Designer-, architect- and engineer-companies
- Manufacturers of insulation, roofing materials, lighting, controls, appliances, and HVAC and energy generation equipment, including those using renewable sources.

Major deliverables

- **Subtask A:**
  - Case studies of completed DER
  - "How-to" Guide with financially attractive core technologies bundles and their characteristics by clime zones
- **Subtask B:**
  - Business and Financial models for deep energy retrofit/refurbishment of buildings and building groups using combined government/public and private funding
- **Subtask C**:
  - Case studies of DER project implemented using combined funding

Definition of Deep Energy Retrofit

Deep Energy Retrofit (DER) is a <u>major building renovation project</u> in which <u>site energy use</u> intensity has been <u>reduced by at least 50%</u> from the pre-renovation baseline.

Some Examples of Deep Energy Retrofit Projects

Residential buildings renovation: 75% energy use reduction
Karlsruhe (Germany)

Residential building renovation:
78% energy use reduction
Freiburg (Germany)

Barracks renovation: 45% energy use reduction, Ft Polk (USA)

More Examples of Deep Energy Retrofit Projects

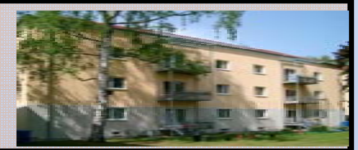
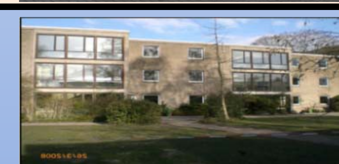
Renovation of the medieval Franciscan monastery in Graz, Austria to Zero Energy building

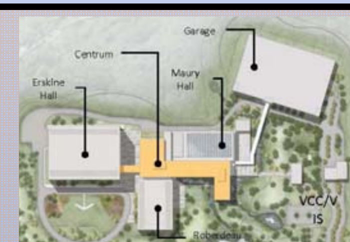
Renovation of a residential building in Kapfenberg (Austria) – renovated to 85% site energy use reduction

Renovation of a kindergarten in Denmark
Primary energy used reduced from
224 kWh/m²/year to 103 kWh/m²/year

Renovation of a school campus in Aachen. Primary energy use reduced from 240 kWh/m²year to 78 kWh /m² year

Annex 61 DER Case Studies (26+)

COUNTRY	SITE	BUILDING TYPE	PICTURES
1.Austria	Kapfenberg	Social housing	
2.Germany	Ludwigshafen-Mundenheim	Multi-stories apartment	
3.Germany	Nürnberg, Bavaria	Multi-stories apartment	
4.Germany	Ostfildern	Gymnasium	
5.Germany	Baden-Württemberg	School	
6.Germany	Osnabrueck	School	
7.Germany	Olbersdorf	School	

COUNTRY	SITE	BUILDING TYPE	PICTURES
8.Germany	Darmstadt	Office building	
9.Denmark	Egedal, Copenhagen	School	
10.USA	Grand Junction, Colorado	Office Building / Courthouse	
11. USA	Silver Spring and Lanham, Maryland	Federal Building/ Office	
12. USA	Intelligence Community Campus, Bethesda , MD	Administrative buildings	
13. USA	St. Croix. Virgin Islands	Office/Courthouse	
14. Estonia	Kindergarten in Valga	Kindergarten	
15. Latvia	Riga	Multi-family building	

“Core Technology” Bundle for DER

Category	Name	Source for characteristics
Building Envelope	Roof insulation	Modeling Results
	Wall insulation	Modeling Results
	Slab Insulation	Modeling Results
	Windows	Modeling Results
	Doors	National Requirements
	Thermal bridges remediation	DER Guide based on best practices
	Air tightness	National the Most Stringent Requirements
	Vapor Barrier	DER Guide based on best practices
	Building Envelope Quality Assurance	DER Guide based on best practices
Lighting and Electrical Systems	Lighting design , technologies and controls	DER Guide based on best practices
HVAC	High performance motors, fans, furnaces, chillers, boilers, etc	National the Most Stringent Requirements
	DOAS	DER Guide based on best practices
	HR (dry and wet)	National the Most Stringent Requirements
	Duct insulation	National the Most Stringent Requirements
	Duct airtightness	National the Most Stringent Requirements
	Pipe insulation	National the Most Stringent Requirements

Core Technology Bundles

- Passive House Institute
- Energy Target: heating < 25kWh/a (site energy), total < 120kWh/a (primary energy),
- Insulation levels for BE components < 0.15 $W/(m^2 K)$ – walls and roofs
- Window characteristics < 0.85 $W/(m^2 K)$
- BE air tightness < 0.6ACH @50Pa
- Thermal bridges mitigation
- HR from return air Eff > 75%
- Project component s certification
- Building post occupancy certification

- DER
- Site energy Target: 50% from the baseline, but better then the minimum national standard
- Insulation levels for BE components by climate zone
- Window characteristics by climate zone
- BE air tightness (e.g., 0.15 cfm/ft2 @75Pa – USA)
- Thermal bridges mitigation
- DOAS
- HR from return air
- Duct air tightness and insulation levels (current national standards)
- Hot and cold water pipe insulation
- Lighting levels and LPD
- Project Delivery Quality Assurance

Subtask A: DER Guide - Outline

- **Introduction**
- **What is Deep Energy Retrofit**
- **Energy efficiency technologies and strategies**
- **Core technologies for DER**
- **Building Envelope**
  - Wall and roof cross-sections
  - Insulation types and levels for different climate conditions
  - Thermal Bridges
  - Window types and characteristics for different climate conditions
  - Air barrier requirements
  - Water and Vapor control for different climate conditions
- **Lighting systems**
- **HVAC systems : core requirements to energy efficiency of equipment, HR, ducts and pipes**

DER Guide – Outline (Cont)

- **Attachments**
  - Insulation Materials
  - Catalogue of thermal bridges
  - Air barrier examples of good and bad practices
  - Windows –good practices and installation recommendations
  - Water and Vapor control: examples of good and bad practices
  - Lighting Design Guide
  - HVAC : examples of energy efficient technologies
- **Quality Assurance**
- **Conclusions**
- **References**

Wall Insulation

Country	U-value W/(m^2*K) (Btu/(hr*ft^2*°F)	R-value (m^2*K)/W (hr*ft^2*°F)/Btu
Austria (c.z. 5A)	0.135 (0.024)	7.4. (42)
c.z.7	0.24 (0.043)	4.17 (23)
China c.z. 7	0.31(0.054)	3.2(19)
c.z. 4A	0.48(0.084)	2.1(12)
c.z. 3A	0.60(0.106)	1.7(9)
c.z. 2A	0.96(0.169)	1.0(6)
c.z. 3C	0.96(0.169)	1.0(6)
Denmark (c.z. 5A)	0.15 (0.026)	6.7 (38)
Estonia (c.z. 6A)	0.17 (0.03)	5.9 (33)
Germany (c.z. 5A)	0.17-0.24 (0.03-0.04)	4.2-5.9 (24-33)
Latvia (c.z. 6A)	0.19 (0.033)	5.3 (30)
UK (c.z. 4A)	0.22(0.039)	4.5(26)
5A	0.22(0.039)	4.5(26)
USA c.z. 1	0.76 (0.133)	1.3 (8)
c.z. 2	0.38 (0.067)	2.6. (15)
c.z. 3	0.28 (0.050)	3.6 (20)
c.z. 4	0.23 (0.040)	4.3 (25)
c.z. 5	0.19 (0.033)	5.3. (30)
c.z. 6	0.14 (0.025)	7.1. (40)
c.z. 7	0.11 (0.020)	9.1 (50)
c.z. 8	0.11 (0.020)	9.1 (50)

Wall Insulation Levels by Country

Country	U-value (SI/IP) W/m²K (BTU/h °F ft²)	R-value (IP) (h °F ft²)/BTU
/BTUAustria (c.z. 5A)	0.12 (0.021)	47.3
China c.z. 7 c.z. 4A c.z. 3A c.z. 2A c.z. 3C	0.124 (0.022) 0.268(0.047) 0.327(0.057) 0.370 (0.065) 0.446(0.079)	46 21.3 17.5 15.4 12.6
Denmark (c.z. 5A)	0.15 (0.026)	37.9
Estonia (c.z. 6A)	0.17 (0.03)	33
Germany (c.z. 5A)	0.2 (0.035)	29
UK (c.z. 4A)	0.22(0.039)	26
USA c.z. 1 c.z. 2 c.z. 3 c.z. 4 c.z. 5 c.z. 6 c.z. 7 c.z. 8	0.76 (0.133) 0.38 (0.067) 0.28 (0.050) 0.23 (0.040) 0.19 (0.033) 0.14 (0.025) 0.11 (0.020) 0.11 (0.020)	7.5 15 20 25 30 40 50 50

Guidance for Insulation Values

Based on modeling results, ranges for insulation levels and windows was developed for various climate zones

DOE Climate Zone 5	Item	Component	Recommendation	
			Assembly Max (2)	Min R-Value (2)
	Roof	Insulation Entirely Above Deck	U-0.020	R-50ci
		Metal Building		R-13 + R-13 + R-34ci
		Vented Attic and Other		R-60
	Walls	Mass	U-0.033	R-30ci
		Metal Building		R-19 + R-17ci
		Steel Framed		R-19 + R-20ci
		Wood Framed and Other		R-19 + R-14ci
		Below Grade/Basement	U-0.067	R-15ci
	Floors Over Unconditioned Space	Mass	U-0.033	R-16 Spray Foam + R-11ci.
		Steel Joist		R-16 Spray Foam + R-13ci.
		Wood Framed and Other		R-19 + R-10ci.
	Slab-on-Grade	Unheated	F-0.54	R-10 for 24 in.
		Heated	F-0.44	R-15 for 36 in. + R-5ci below
	Doors	Swinging	U-0.60	Insulated
		Non-Swinging	U-0.40	Insulated

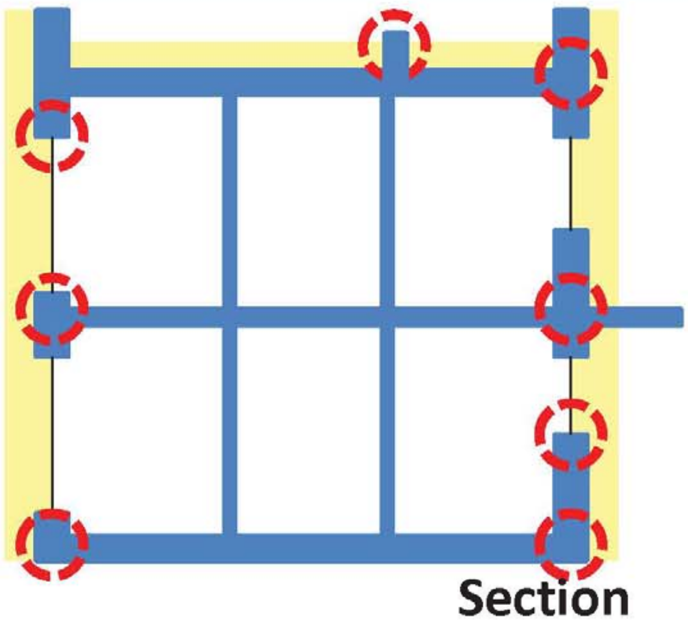
Roof Insulation

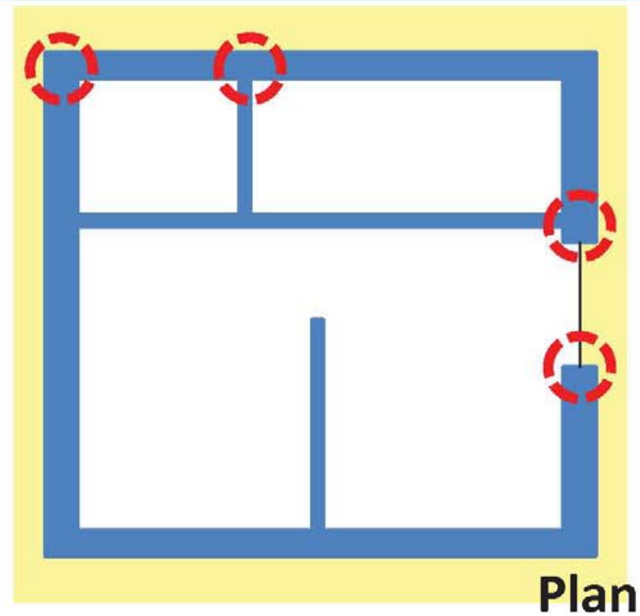
Country	Climate zone	U-value W/(m²*K) (Btu/(hr*ft²*°F)	R-value (m²*K)/W (hr*ft²*°F)/Btu
Austria	4a 7	0.159 (0.028) 0.23 (0.041)	6.3 (36) 4.4 (25)
China	2a 3a 3c 4a 7	0.53 (0.093) 0.53 (0.093) 0.53 (0.093) 0.38(0.067) 0.30 (0.053)	1.9(11) 1.9(11) 1.9(11) 2.6(15) 3.3(19)
Denmark	5a	0.10 (0.018)	1 (57)
Estonia	6a	0.11 (0.02)	9.1 (52)
Germany	5a	0.14 (0.025)	7.1 (40)
Latvia	6a	0.16 (0.029)	6.3 (35)
UK	4a 5a	0.13(0.023) 0.13(0.023)	7.7 (44) 7.7 (44)
USA	1 2 3 4 5 6 7 8	0.16 (0.029) 0.14 (0.025) 0.12 (0.022) 0.12 (0.022) 0.11 (0.020) 0.09 (0.0167) 0.09 (0.0154) 0.08 (0.0133)	6.3 (35) 7.1 (40) 8.3 (45) 8.3 (45) 9.1 (50) 11.1 (60) 11.1 (65) 12.5 (75)

Windows

Country	U-value W/(m²*K) (Btu/(hr*ft²*°F)	R-value (m²*K)/W (hr*ft²*°F)/Btu	SHGC
Austria (c.z. 5A) c.z.7	1.09 (0.19) 1.09 (0.19)	0.92 (5.3) 0.92 (5.3)	0.60 0.60
China c.z. 2A c.z. 3a c.z. 3C c.z. 4A c.z. 7	 2.55(0.45) 2.55(0.45) 2.70(0.48) 1.79(0.32) 1.79(0.32)	 0.39 (2.2) 0.39 (2.2) 0.37 (2.1) 0.56 (3.1) 0.56 (3.1)	 0.48 0.48 0.48 0.68 0.68
Denmark (c.z. 5A)	1.2 (0.21)	0.83 (4.8)	0.63
Estonia (c.z. 6A)	1.1 (0.19)	0.91 (5.3)	0.56
Germany (c.z. 5A)	1.3 (0.23)	1.0 (5.7)	0.55
Latvia (c.z. 6A)	1.2 (0.21)	0.83 (4.8)	0.43
UK (c.z. 4A) c.z. 5A	1.32 (0.23) 1.79 (0.32)	0.76 (4.3) 0.56 (3.1)	0.48 0.68
USA c.z. 1&2 c.z. 3&4 c.z. 5 c.z. 6 c.z. 7 c.z. 8	1.98 (< 0.35) 1.70 (< 0.30) 1.53 (< 0.27) 1.36 (< 0.24) 1.25 (< 0.22) 1.02 (< 0.18)	> 0.51 (2.9) > 0.59 (3.3) > 0.65 (3.7) > 0.74 (4.2) > 0.80 (4.5) > 0.98 (5.6)	< 0.25 0.30- 0.35 0.35- 0.40 >50 >50 >50

Thermal Bridges

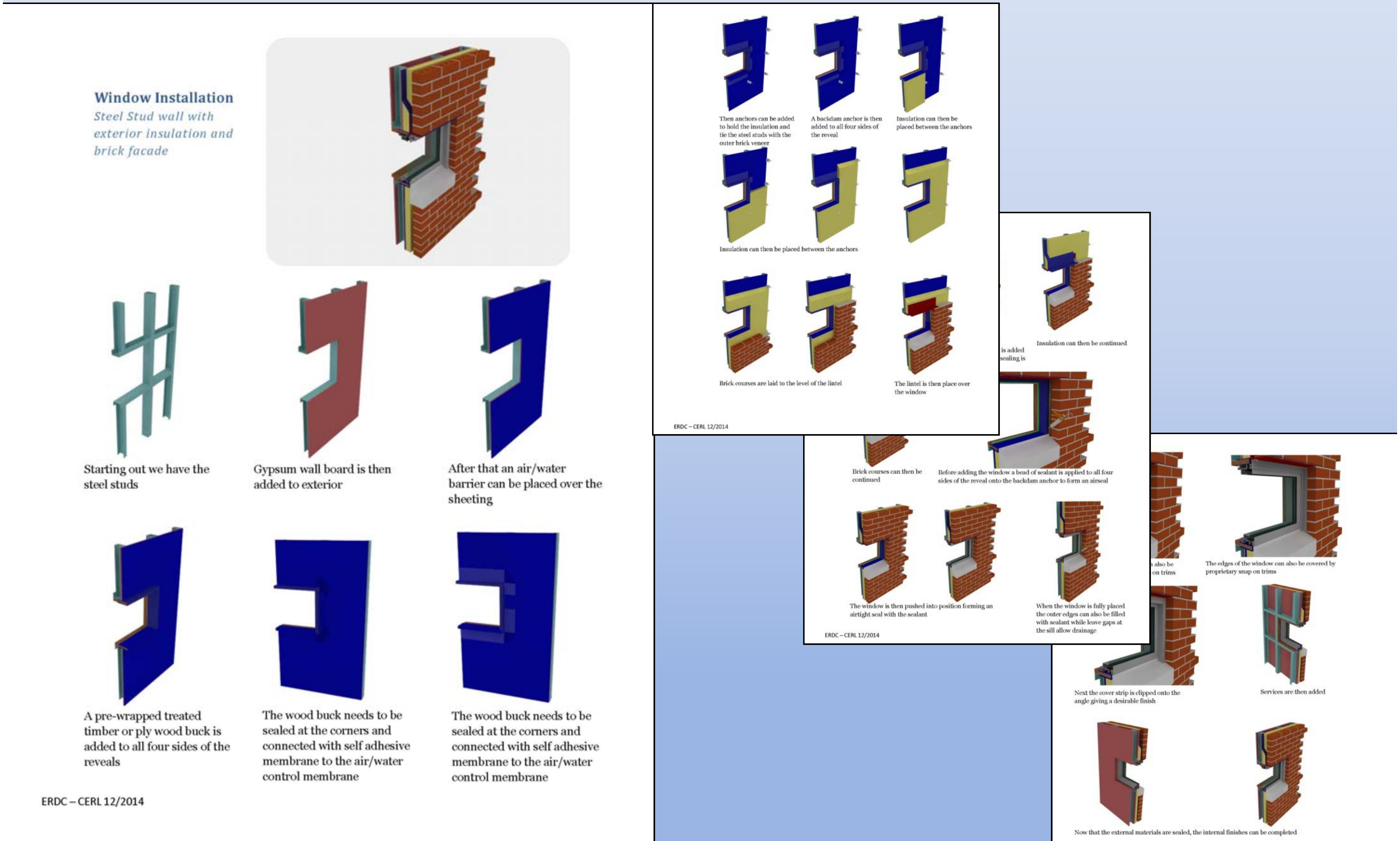




Details of Major Magnitude
1. At Eaves/Ridge
2. Window and Door Fitting – Head, Sill and Jamb
3. At Projections, Shades Or Intermediate Floors
4. Internal Walls to External Walls
5. Intermediate Floors
6. At Grade

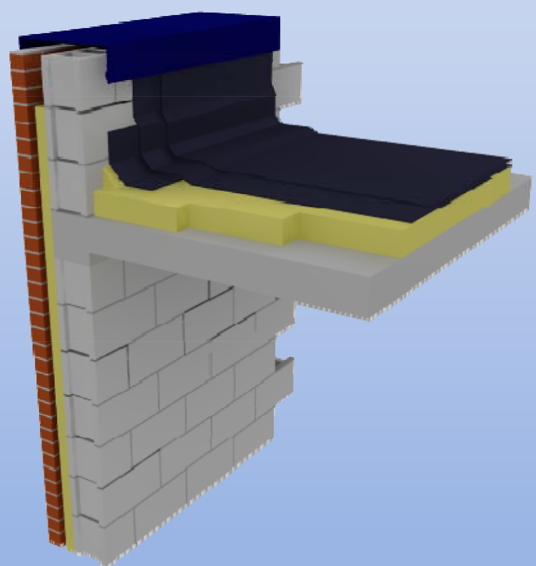
Details of Minor Magnitude
1. Wall Corner – Never Usually an Issue
2. Threshold or Door
3. Duct and Service Connections
4. Penetrations at Installations in Roof; PV or Water Tanks

Example of Window Replacement Sequencing
(with improved insulation, air and thermal barriers)

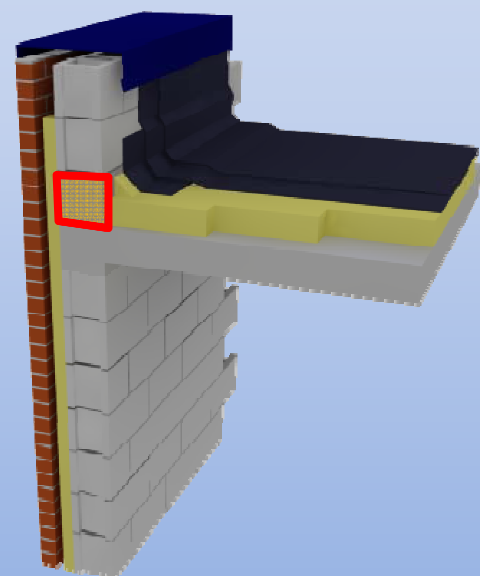


Thermal Bridge Remediation

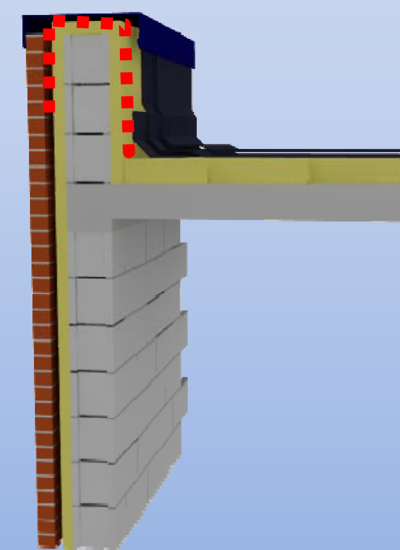
Typical detail poor thermal bridge



Insert thermal break



Wrap the parapet



Example

2f Window Sill in CMU or Concrete Wall with Exterior Insulation

Notes

After removing the existing brick sill, make the insulation continuous and aligned with the window thermal break- key to the success of this detail is ensuring good structural attachment of the window and the alignment of the window thermal break. This offers chance to improve the window air tightness and rain control performance as well.

Sub-sill flashing is required for rain control. It should posses a raised vertical section at the back (called "backdam"), tall enough allowing the installation of sealant between it and the window (for major both, water and airflow control continuity)

Use metal flashing only to cross part of the insulation and take water to the exterior. Polymeric, self-adhered membranes can be used to connect the water control layer on the face of the wall to the metal flashing.

The hollow space of open window frames will promote natural convective heat flow through it. This undesired heat flow can be reduced by filling these voids with factory-installed custom-shaped foam plastic or rigid stone sections.

To support the outer portion of a window with a single lite so that its thermal break is aligned with wall insulation, the window support should be installed below the IGU.

Existing Window Sill

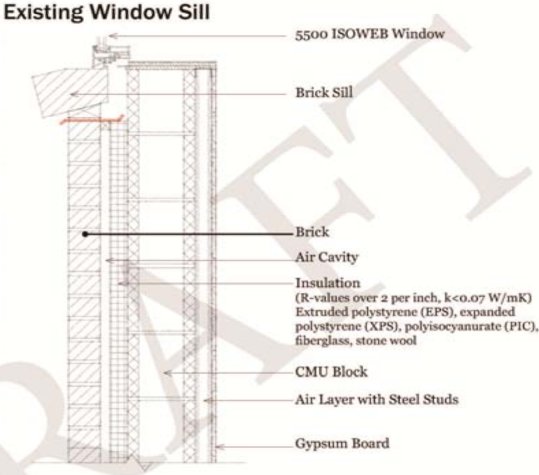
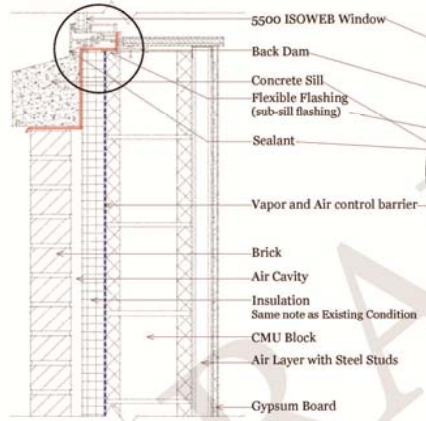


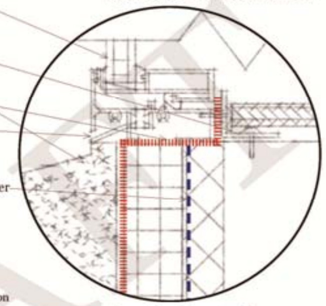
Table of Modeling Values

Component	Thickness Inches (mm)	Conductivity Btu/h•ft•°F (W/m K)	Nominal Resisitance hrft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)
Interior Film	-	-	R-0.74 (0.13 RSI)	-
Brick	3 5/8" (92)	0.578 (1)	R-0.523 (0.092 RSI)	110 (1800)
Air Cavity	1" (25)	0.070 (0.122)	R-1.185 (0.209 RSI)	-
Insulation	2" (51)	0.0139 (0.024)	R-11.99 (2.112 RSI)	-
CMU Block	7 5/8" (194)	0.069 (1.2)	R-0.916 (0.161 RSI)	130 (2100)
Air Layer with Steel Studs	1 3/4" (44)	0.2219 (0.384)	R-0.66 (0.116 RSI)	-
Gypsum Board	1/2" (13)	0.092 (0.16)	R-0.5 (0.08 RSI)	50 (800)
5500 ISOWEB WINDOW	-	-	-	-
Aluminum Sill Flashing	12 Gauge	160	-	-
Brick Sill	3 5/8" (92)	0.578 (1)	-	110 (1800)
Exterior Film	-	-	R-0.23 (0.04 RSI)	-

Corrected Window Sill



Close up of the Corrected Window Sill



Thermal Performance

Condition	Clear Wall R-Value (W/m2K)	Linear Transmittance (Ψ) Btu/h•ft•°F (W/mK)
Wall Clear Field	R-15.7 (0.369)	-
Existing Fitting Situation	-	**0.445 (0.771)**
Corrected Fitting Situation	-	**0.017 (0.030)**

1. Thermal analysis based on 5500 ISOWEB WINDOW- thermally broken window selection.
2. The performance of the correct version can be improved only slightly from Ψ - 0.017 Btu/h•ft•°F using thicker insulation and tweaking the details of the window sill attachment to the window and the alignment of the thermal break.
3. The reported Ψ-value does not include the metal angle backdam or anchors thermal effects.

Quality Control/ Sequencing

1. Remove old window
2. Remove brick sill, flashing and window board
3. Insert sheet metal back dam at the top surface where the existing brick sill was laying
4. Insert additional insulation to rear of sill
5. Insert additional Insulation plus wood buck
6. Insert flexible flashing
7. Insert backdam anchor
8. Insert pre-shimmed glazing tape air and water seal, joining the air and moisture barriers with the metal angle backdam and flexible flashing.
9. Insert new brick sill
10. Insert sealant
11. Hinge window into position and brace to backdam anchor
12. Add window board

Building Air Tightness

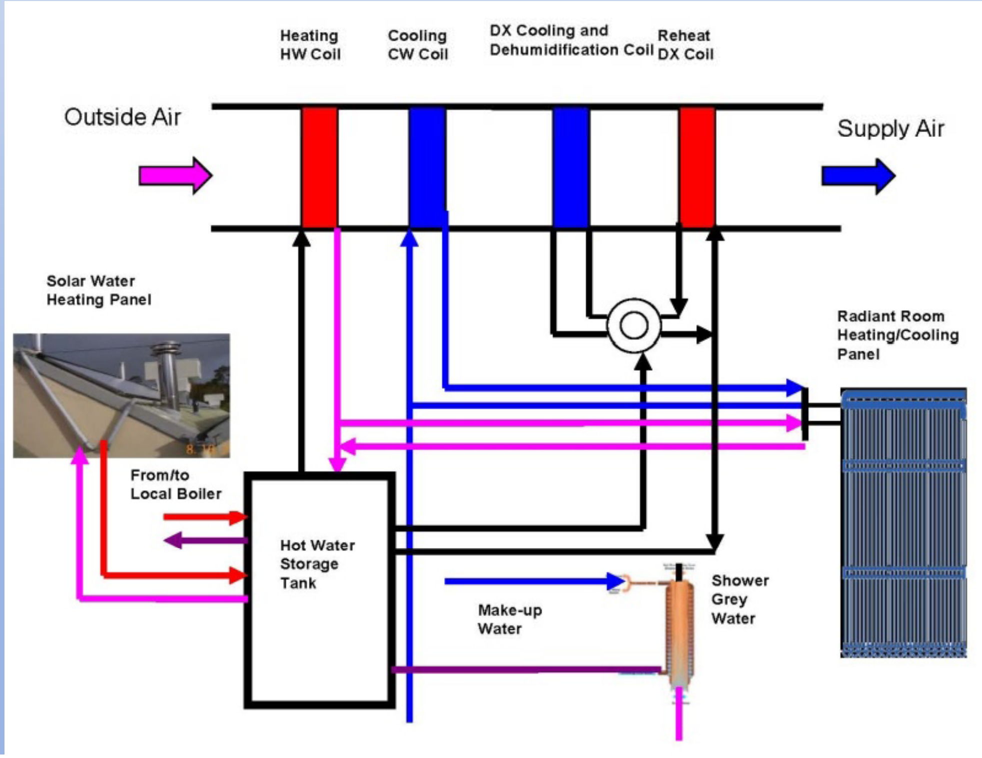
Country	Source	Requirement*	cfm/ ft^2 at 75Pa
Austria	OIB RL 6, 2011 for buildings with mechanical ventilation	1.5 1/h at 50 Pa	**0.28**
Germany	DIN 4108-2	1.5 1/h at 50 Pa	**0.28**
USA	ASHRAE Standard 90.1 - 2013 USACE ECB for all buildings [21]		**0.25**
USA	USACE HP Buildings and DER proposed requirement		**0.15**
UK	TS-1Commercial Tight	2 $m^3/h/m^2$ at 50 Pa	**0.14**
CAN	R-2000	1 sq in EqLA @10 Pa /100 sq ft	**0.13**
Germany	Passive House Std	0.6 1/h at 50 Pa	**0.11**

Based on four-story building, 120 x 110 ft, n=0.65.

Advanced HVAC Systems

- Dedicated outdoor air system (DOAS)
- Heating and Cooling equipment per current national standard (e.g., ASHRAE 90.1-2013)
- Heat recovery (sensible and latent) > 80% efficiency
- Duct air tightness – class C
- Hot and chilled water pipes insulation per current national standard

- Low exergy heating and cooling systems: indirect evaporative cooling (e.g., Coolerado), radiant heating and cooling, energy flow cascading, etc.



Lighting – Improved Design and Technology

Lighting Design Guide for Low Energy Buildings – New and Retrofits

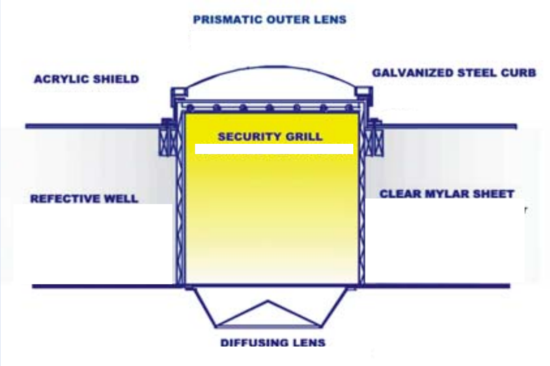
Improved Design
Reduced illuminance
Reduced electrical power

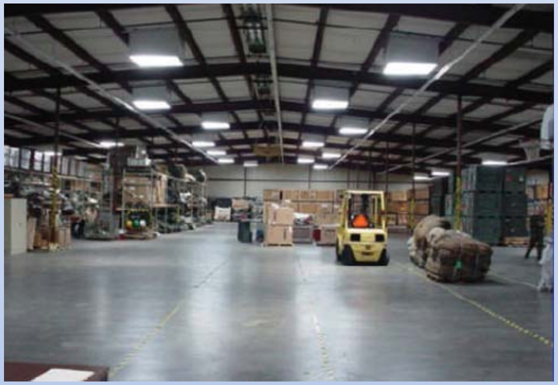
RECOMMENDED LIGHTING POWER DENSITY AND ILLUMINANCE VALUES

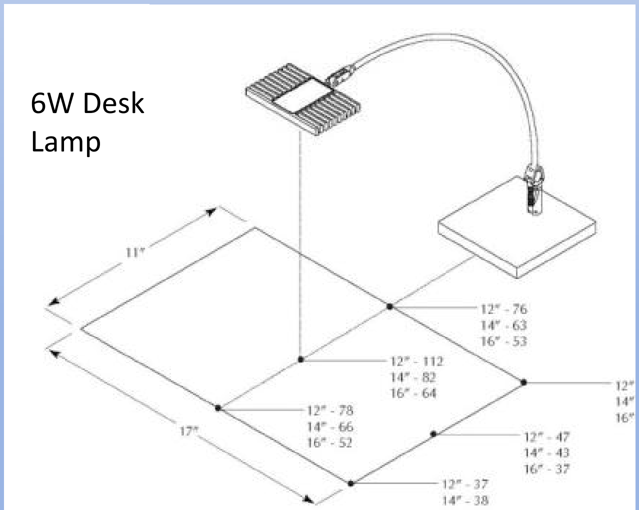
Space Type	Target Illuminance	Target LPD
Common Spaces		
- Conference Room	40 fc	0.80 W/ft^2
- Corridor	10 fc	0.50 W/ft2
- Dining	20 fc	0.60 W/ft2
- Dishwashing/ Tray Return	50 fc	0.65 W/ft2
- Kitchen/ Food Prep/ Drive Thru	50 fc	0.65 W/ft2
- Living Quarters	5-30 fc	0.60 W/ft2
- Mechanical/ Electrical	30 fc	0.70 W/ft2
- Office (Open)	30-50 fc	0.70 W/ft2
- Office (Enclosed)	30-50 fc	0.80 W/ft2
- Reception/Waiting	15-30 fc	0.50 W/ft2
- Restroom/ Shower	20 fc	0.80 W/ft2
- Server Room	30 fc	0.85 W/ft2
- Serving Area	50 fc	0.70 W/ft2
- Stair	10 fc	0.50 W/ft2
- Storage (general)	10 fc	0.50 W/ft2
- Storage (dry food)	10 fc	0.70 W/ft2
- Telecom / Siprnet	50 fc	1.20 W/ft2
- Vault	40 fc	0.70 W/ft2
Training		
- Readiness Bay	40 fc	0.75 W/ft2
- Training Room (Small)	15-30 fc	0.70 W/ft2
Vehicle Maintenance		
- Consolidated Bench Repair	50 fc	0.60 W/ft2
- Repair Bay/ Vehicle Corridor	50 fc	0.85 W/ft2

Lighting Controls

- Use daylight responsive controls in frequently occupied spaces with daylight access
- Use vacancy sensors in spaces with daylight access
- Use occupancy sensors in spaces without daylight access
- Control lighting with time-clocks for building-wide energy conservation






6W Desk Lamp

Quality Assurance Includes

- Detailed technical specification, against which tenders will be made, and verification of understanding of these specifications by potential contractors,
- Specification in SOW/OPR of areas of major concern to be addressed and checked during the bid selection, design, construction, commissioning and post-occupancy phases;
- Clear delineation of the responsibilities and qualifications of stakeholders in this process.

QA Process Phases

- RFP and SOW provides clear and concise documentation of the Owner's goals, expectations and requirements to the renovated building and shall be utilized throughout the project delivery, provides an informed baseline and focus for design development and for validating building' energy and environmental performance. Based on this document, bidders will be able to offer a matching perspective;

- Procurement phase, which includes analysis of bidders qualifications, their understanding of the statement of work and its requirements; previous experience and ability to coordinate different trades and deliver the renovated building which will meet specifications;

- Design Phase with Design Reviews;

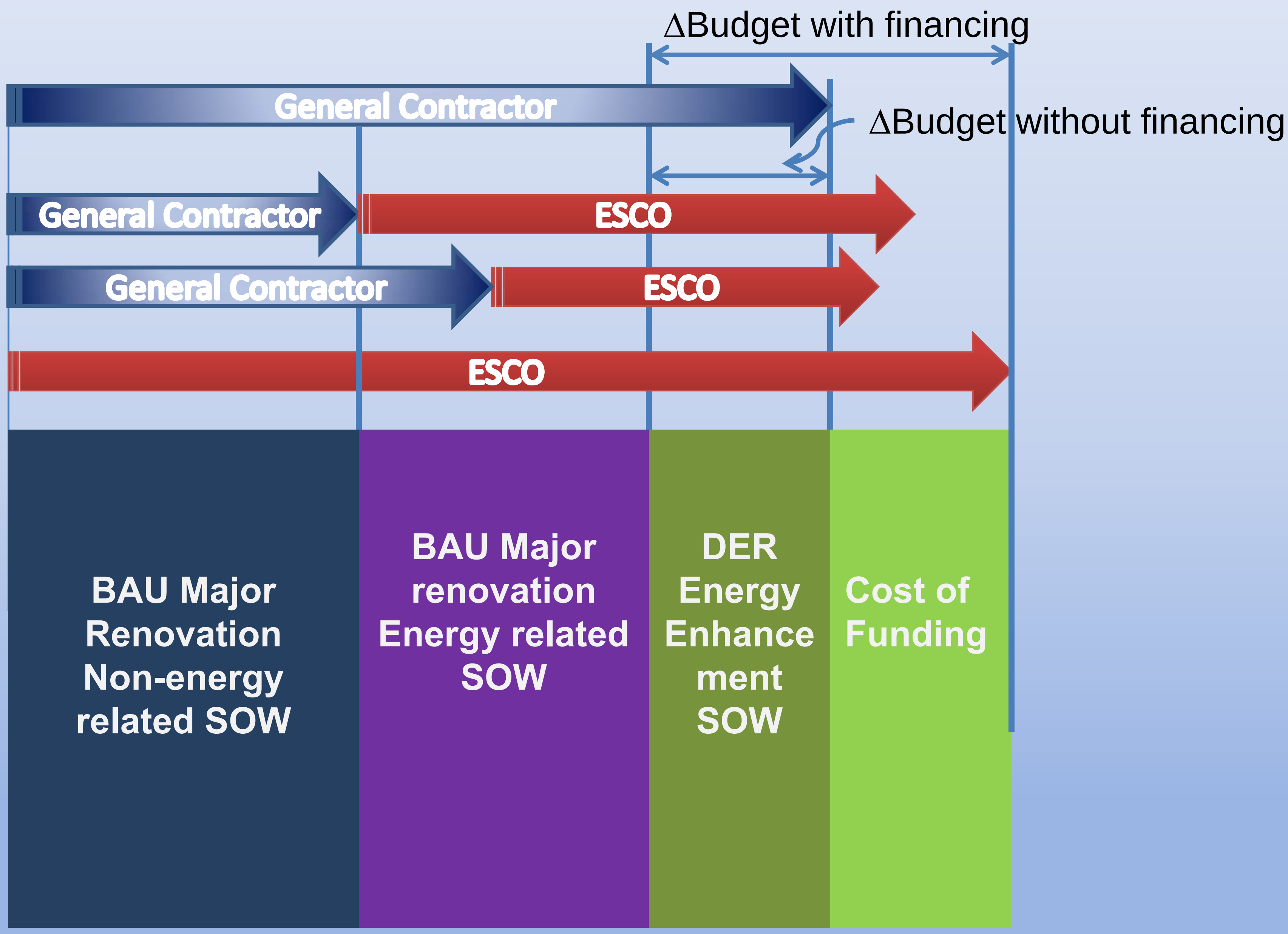
- Construction and whole building commissioning, and

- Post occupancy evaluation

Statement of Work and Bidding Process

- Contractually binding specific energy targets (i.e., EUI for site and primary energy, kWh/m^2 per year, energy security and system redundancy requirements) to be achieved through the building renovation, parameters and qualities of materials; components and building systems to be used; installation methods; testing and commissioning methods which will be used for verification throughout the design, construction and post occupancy phases.
- During the bidding and design phases the contractor will provide results of energy modeling to demonstrate theoretical feasibility of meeting energy targets
- Pre-renovation building model shall be calibrated against the utility data.
- Contractor presents a review of the energy requirements for the project to include site and source energy targets; energy calculation and modeling methodologies; and discusses and resolves any conflicts or questions to the SOW/OPR.

DER Implementation Strategies



Allowable (Cost Effective) Budget Increase for DER

$$\Delta \text{ Budget}_{max} = \text{NPV} [\Delta \text{ Energy (\$)}] + \text{NPV} [\Delta \text{Maintenance (\$)}] + \text{NPV} [\Delta \text{Replacement Cost (\$)}] + \text{NPV} [\Delta \text{Lease Revenues (\$)}]$$

$$\Delta \text{ Budget}_{max} = SR_E [\Delta \text{ Energy (\$)}] + S_M [\Delta \text{Maintenance}] + S_L [\Delta \text{Lease Revenues}]$$

$$\text{NPV} [\Delta G \times C_G] = [\Delta G]_{t=1} \times C_{G(t=1)} \times (1+e)/d\text{-}e) \times [1- (1+e)/1+d)]^N = [\Delta G]_{t=1} \times C_{G(t=1)} S_E$$

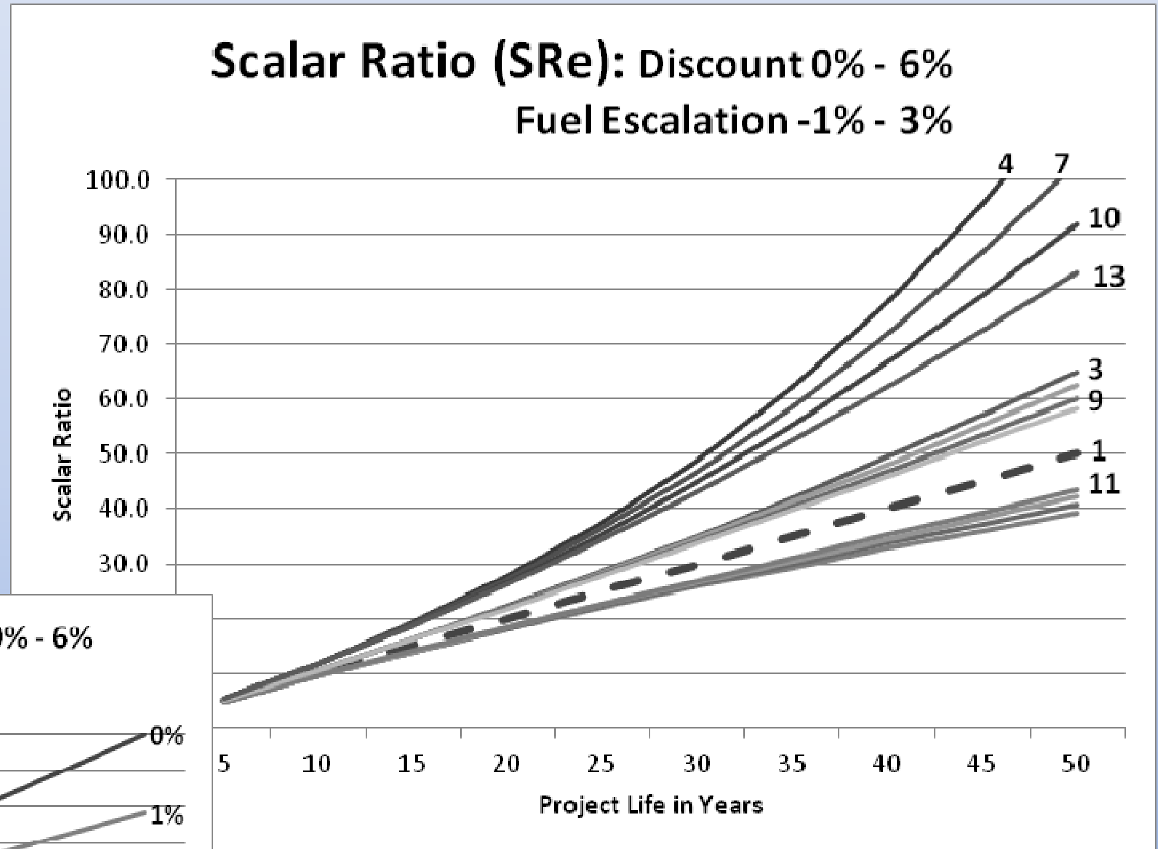
S_M and S_L scalars can be calculated and are the uniform present worth factor Series that use the discount rate, the same way as SR_E with the escalation rate e=0%.

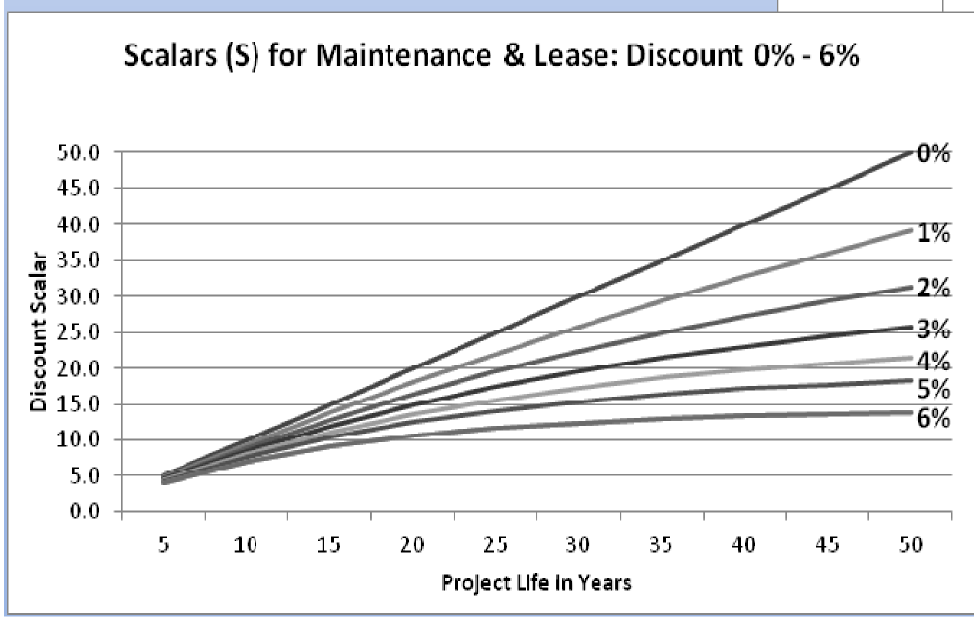
NPV = Net Present Value function
N = study life in years
d = discount rate
e –escalation rate

Examples of SR or selected economic project life, interest, discount and escalation rates.

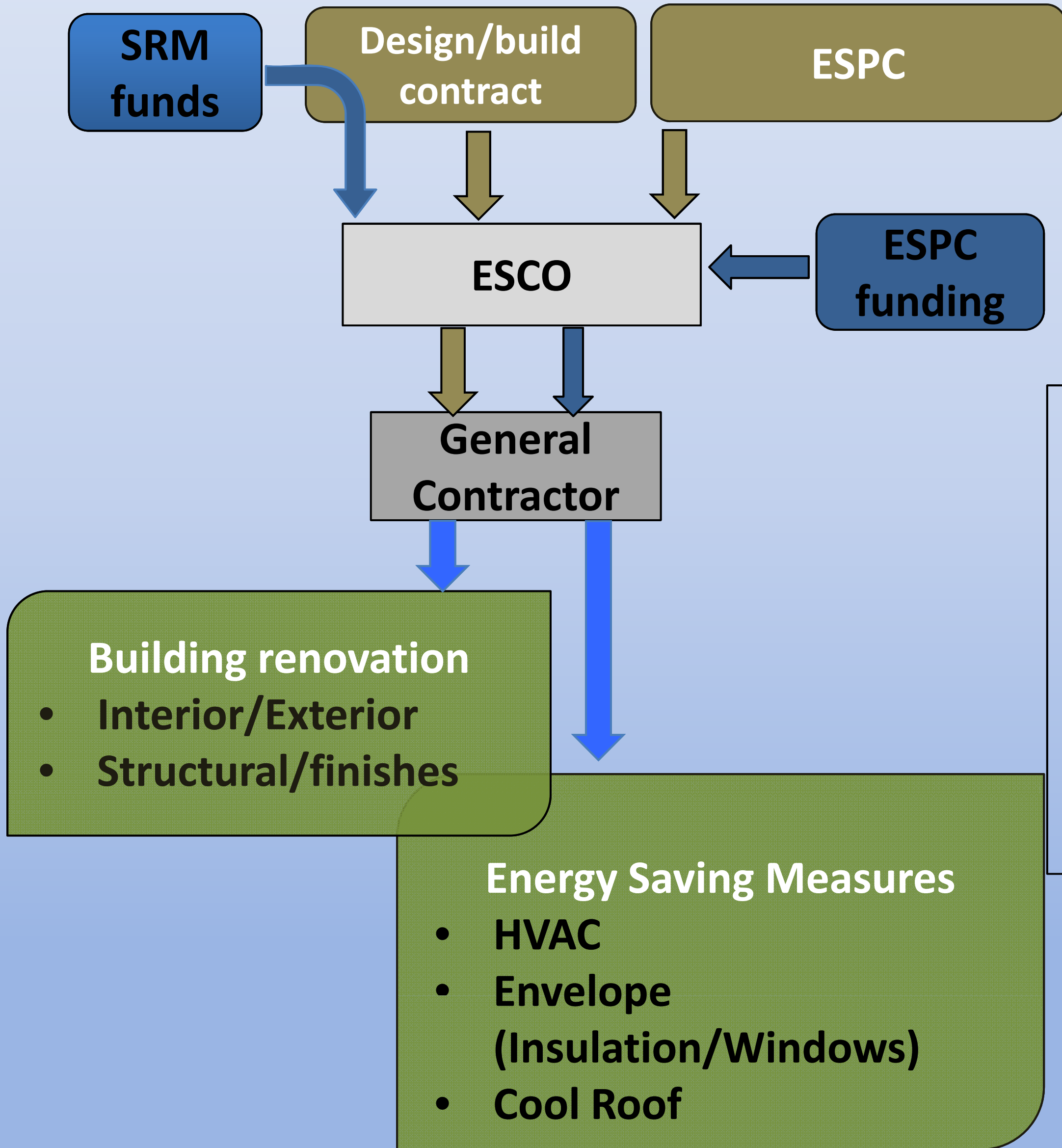
No.*	Economic Life (yrs)		5	10	15	20	25	30	35	40	45	50
	Discount	Escalation										
1	0%	0%	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
2	0%	-1%	4.9	9.5	13.9	18.0	22.0	25.8	29.4	32.8	36.0	39.1
3	0%	1%	5.2	10.6	16.3	22.2	28.5	35.1	42.1	49.4	57.0	65.1
4	0%	3%	5.5	11.8	19.2	27.7	37.6	49.0	62.3	77.7	95.5	116.2
5	2%	-1%	4.9	9.5	13.9	18.1	22.2	26.2	30.0	33.6	37.2	40.7
6	2%	1%	5.1	10.5	16.2	22.1	28.2	34.6	41.2	48.1	55.2	62.5
7	2%	3%	5.5	11.8	18.9	27.1	36.4	46.9	58.7	71.9	86.6	103.0
8	4%	-1%	4.9	9.5	14.0	18.3	22.4	26.5	30.5	34.4	38.3	42.2
9	4%	1%	5.1	10.5	16.1	22.0	28.0	34.1	40.5	46.9	53.5	60.2
10	4%	3%	5.5	11.7	18.7	26.6	35.4	45.0	55.4	66.7	78.9	91.8
11	6%	-1%	4.9	9.5	14.0	18.4	22.6	26.9	31.0	35.2	39.3	43.4
12	6%	1%	5.1	10.5	16.1	21.8	27.7	33.7	39.8	45.9	52.1	58.4
13	6%	3%	5.4	11.6	18.6	26.2	34.4	43.2	52.5	62.3	72.5	83.0
*These data (indicated by "No.") relate to the curves in Figure 2a.												
Scalars for Maintenance and Leases below, Escalation = 0%												
1	0%	0%	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
2	1%	0%	4.9	9.5	13.9	18.0	22.0	25.8	29.4	32.8	36.1	39.2
3	2%	0%	4.7	9.0	12.8	16.4	19.5	22.4	25.0	27.4	29.5	31.4
4	3%	0%	4.6	8.5	11.9	14.9	17.4	19.6	21.5	23.1	24.5	25.7
5	4%	0%	4.5	8.1	11.1	13.6	15.6	17.3	18.7	19.8	20.7	21.5
6	5%	0%	4.3	7.7	10.4	12.5	14.1	15.4	16.4	17.2	17.8	18.3
7	6%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
8	7%	0%	4.1	7.0	9.1	10.6	11.7	12.4	12.9	13.3	13.6	13.8

Scalar Ratio for Fuels at varying Discount and Fuel Escalations Rates SR_e and Scalars for Maintenance and Lease S.





SRM-ESPC Deep Retrofit Project Model #1



- ESCO is awarded design/build contract for non-energy-related building renovation, and ESPC for energy-related measures
- ESCO hires a GC, but provides single point of contact for Army

Questions, Comments, Want to be a part of the TEAM?

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