How to achieve Deep Energy Retrofit in a cost effective way?

Annex 61

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Deep Energy Retrofit (IT-Tool)

Graz, Austria

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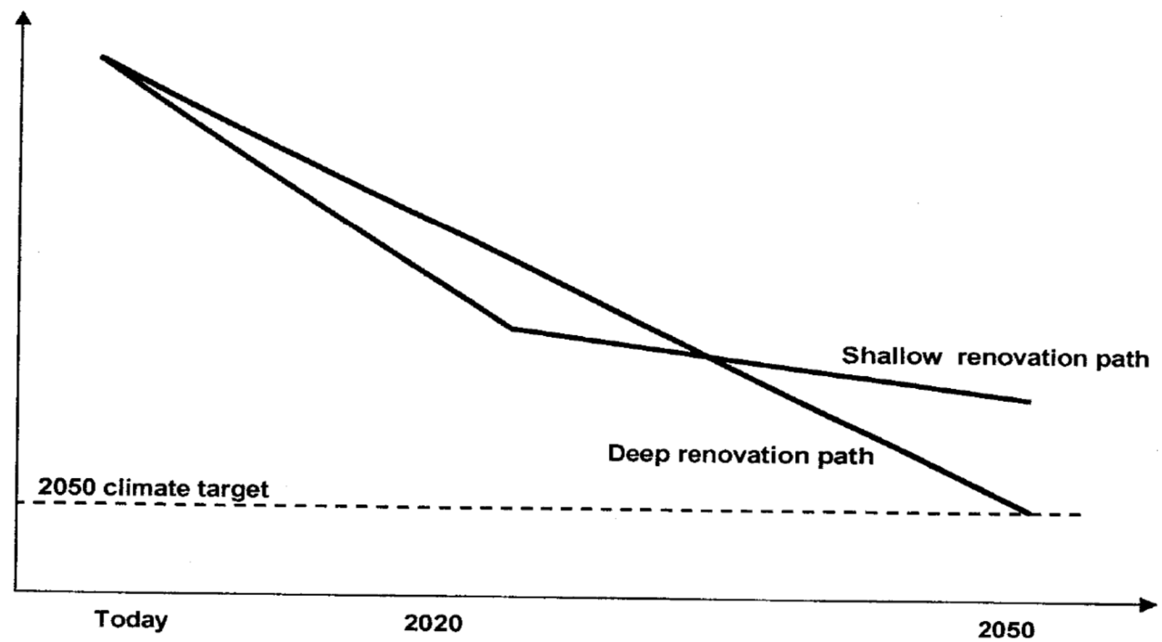
Background

- 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)

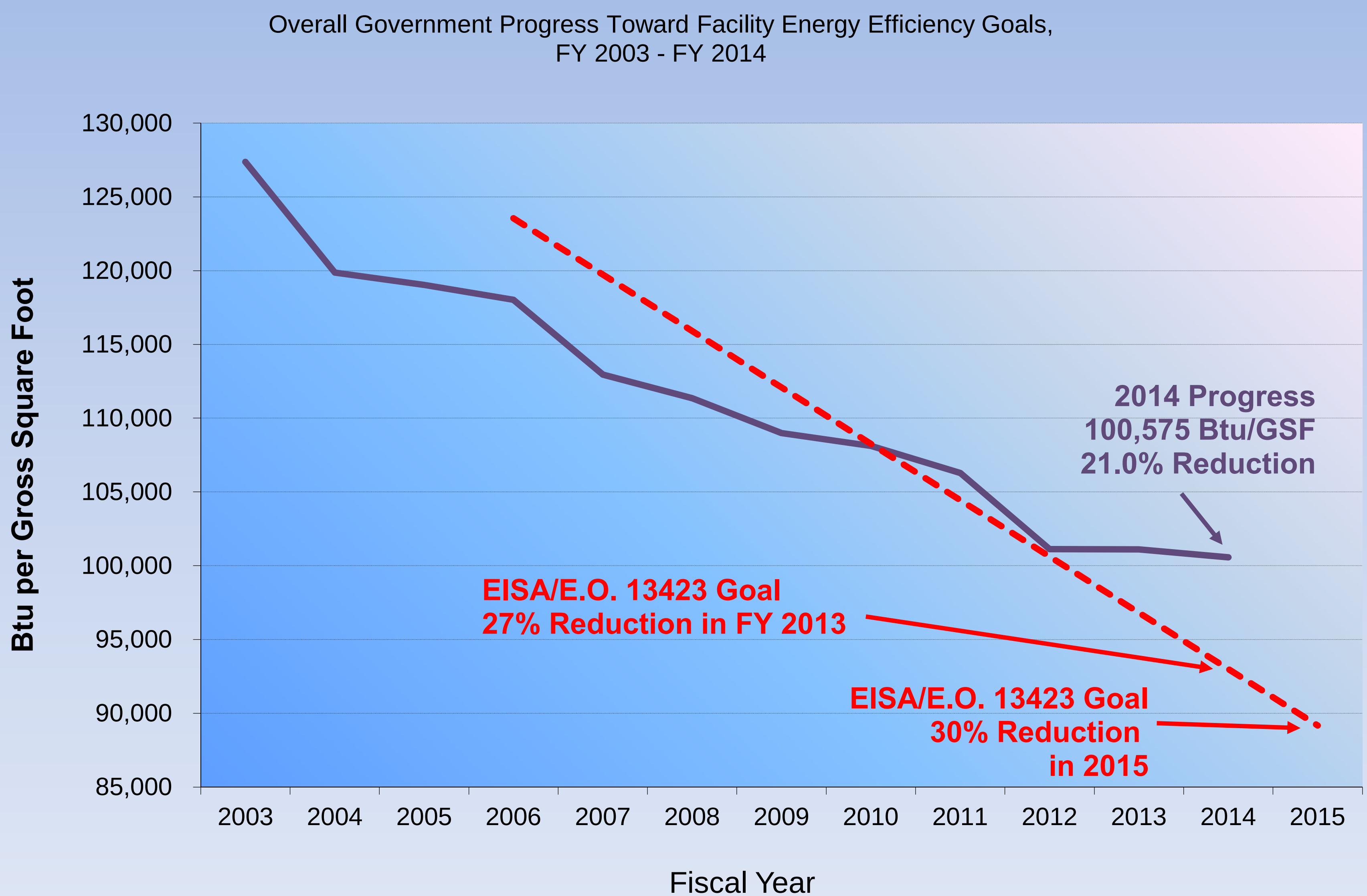
How to Meet Energy Goals?



The speed trap of shallow renovation (from "Economics of Deep Renovation", Ecofys 2011

Using available annual budget for many cheaper shallow renovations saving , instead of using fewer, more expansive deep energy renovations saving may lead to unwanted, irreversible long-term consequences. For meeting short term goals "shallow renovation" with the best ROI ratio may look better, than a deep energy renovation strategy, while it will fail to achieve long term energy goal.

US Federal Facilities: Energy Intensity (Btu/GSF) Reduction Vs. Goal



PRELIMINARY DATA

Annex 61 Objectives

- To provide a framework and selected tools and guidelines to significantly reduce energy use (by more than 50%) in *public buildings undergoing major renovation*
- To gather and, in some cases, 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 buildings* using appropriate combinations of public and private funding

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.

Subtasks

- **Subtask A:** Bundles of Technology: Prepare and evaluate case studies on existing deep energy retrofit concepts. Develop a guide for achieving financially attractive deep energy retrofits of buildings and building communities.
- **Subtask B -** Develop business models for deep energy retrofit of buildings using combined government/public and private funding

Subtasks (Continued)

- **Subtask C:** Demonstrate selected deep energy retrofit concepts using combined government/public and private funding, and prepare case studies describing completed and/or partially completed projects.
- **Subtask D:** Develop an IT-tool for decision-makers and ESCOs that emphasizes low-risk approaches for early stages of design and decision-making.

Current Minimum Energy Related Requirements

Country	Building Energy	Building Envelope	HVAC	Lighting
Austria	OIB Directive Nr.6	OIB RL 6, 2011	EN 1507, EN 12237 ÖNORM H 5057, OIB RL 6, 2011	EN 12464-1 and -2 EN 15193
China	GB50198-2005	GB50198-2005, GB/T 7016-2008	GB 50243-2002 GB50736-2012 GB50198-2005	GB50034-2004
Denmark	Danish Building Regulation 2010, DS Standard 418	Danish Building Regulation 2010	Standard 447 Standard 452	DS/EN ISO 12464-1
Estonia	Ordinance No. 63. RT I, 18.10.2012, 1, 2012; Ordinance No. 68. RT I, 05.09.2012, 4, 2012	EVS-EN ISO 10077, EVS-EN 1026 EVS-EN 12207 EVS-EN 12208	EVS-EN 13779, EN 12237 Ordinance No. 70. RT I, 09.11.2012, 12	Ordinance No. 70. RT I, 09.11.2012, 12
Germany	DIN 18599- 1; EnEV 2014	EnEV 2014, DIN 18361 DIN 18355 , DIN V 18599/2 DIN 4102, DIN 4108 DIN EN 13162, DIN EN 13163 DIN EN 13164, DIN EN 13165 DIN EN 13167, DIN EN 13171	EnEV 2014, DIN V 18599- 2 and 7 DIN 1946- 6, DIN EN 13779 DIN 24192 II/III/IV DIN 4108- 6, DIN 4701- 10, EnEV 2009/2014	DIN 18599- 4, DIN 5035 T 1- 14
UK	BS EN 15603:2008	Building Regulations-Conservation of Fuel and Power in New Buildings Other Than Dwelling: Part L2A.	BS EN 15727:2010 BS 5422:2009 Non-Domestic Building Services Compliance Guide:2013	BS EN 12464-1:2011
USA	ASHRAE Std 90.1 2010 ASHRAE Std 100 2015	ASHRAE Std 90.1 2010	ASHRAE Std 90.1 2010	ASHRAE Std 90.1 +IESNA recommended practices, 10th edition 2010

Major Renovation: BAU

Examples of calculated % of energy use reduction with major renovation projects from pre-1980 baseline to current minimum energy standards

- USA :
  - Barracks (c.z. 1A – 8) EUI_{site}: **8-16**%
  - Administrative building: EUI_{site}: **8-22**%
- German Administrative Buildings (c.z. 5A) EUI_{site}: **40**%
- Danish School (c.z.6A): EUI_{site}: **19**%;
- Austrian residential building (c.z. 5A): EUI_{site}: **29**%

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."

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- To develop and demonstrate *innovative, highly resource-efficient business models for retrofitting/refurbishing buildings* using appropriate combinations of public and private funding

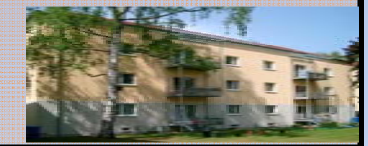
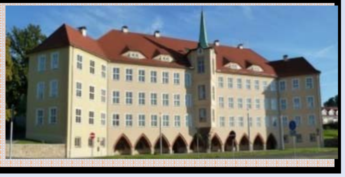
Annex 61 Definition of Deep Energy Retrofit

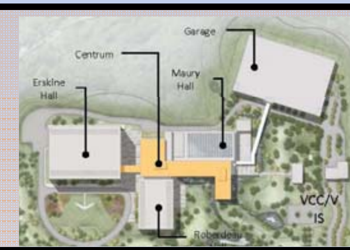
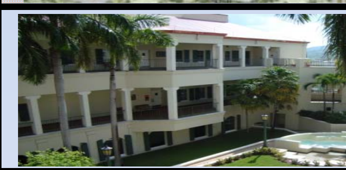
Deep Energy Retrofit (DER) is a major building renovation project in which site energy use intensity has been reduced by at least 50% (including plug-loads) from the pre-renovation baseline.

How to Achieve DER ?
European Experience

Measure	Germany	Austria	Denmark
Wall insulation	12-24 cm (0.20-0.10 W/m^2K)	16 -20 cm (0.20 - 0.10) W/m^2K	15-30 cm
Roof insulation	20 – 40 cm (0.20- 0.10 W/m^2K)	20 – 40 cm (0.20- 0.10 w/m^2K)	20-40cm
New Windows	0.8-1.1 W/m^2 K	triple glazing (0.70 – 0.90 W/m^2K)	U-value down to 0.5-1.2 W/m^2 K
Unheated basement ceiling insulation	5-20 cm (0.25- 0.10 W/m^2K)	10 – 20 cm (0.20 – 0.10 W/m^2K)	10-20cm
Reduction of thermal bridges	Reduction as good as reasonably possible		Foundation: < 0.15W/mK Windows: < 0.8-0.5 W/mK
Improved building envelope air tightness	n50 value = 1.0 1/h - 0.6 1/h (Low-energy buildings + (Passive houses)	n50 value = 1.0 1/h - 0.6 1/h (Low-energy buildings + Passive houses)	q(50pa): from 4l/s/m² to 1.5l/s/m²
Ventilation system heat recovery	Heat recovery rate: 65 – 80%	Heat recovery rate 65 – 80%	SEL: down to:1.5-1.2kJ/m³
Solar Thermal Collectors for DHW	Dwellings: 3- 5 m² /+500- 800 l storage per residential unit, NRB with 2- 3 m² per shower unit + 300-400 l/ storage per unit	In some provinces (e.g. Styria) residential buildings are obliged to have solar thermal collector	Dwellings: 3-5m²
Advanced lighting system design with day-lighting controls	Dwellings: 10- 12 m² high efficient solar evacuated tube collector + > 1,000 l storage/ unit s		With daylight and dimming control.

Annex 61 DER Case Studies (27+)

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	

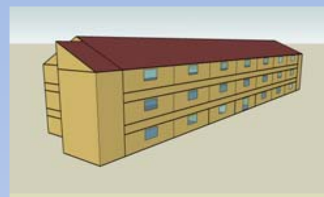
COUNTRY	SITE	BUILDING TYPE	PICTURES
8.Germany	Darmstadt	Office building	
9.Denmark	Egedal, Copenhagen	School	
10.USA	Grand Junction, Colorado	Office Building / Courthouse	
11. USA	Silver Spring and Lanham, Maryland	Federal Building/ Office	
12. USA	Intelligence Community Campus, Bethesda , MD	Administrative 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

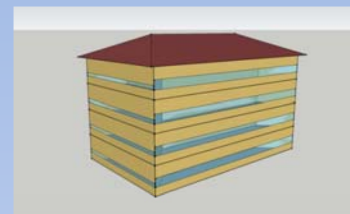
Category	Name	Source for characteristics
Building Envelope	Roof insulation	Modeling Results
	Wall insulation	Modeling Results
	Slab Insulation	Modeling Results
	Windows	Modeling Results
	Doors	National Requirements
	Thermal bridges remediation	DER Guide based on best practices
	Air tightness	National 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

Building Models used by the Modeling Team

USA, ERDC
Climate Zones 1-8



Barracks

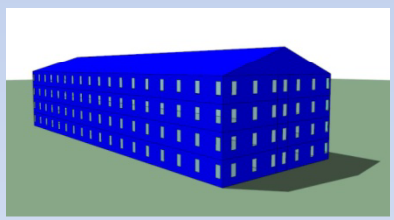


Office, Battalion HQ

Estonia, TTU

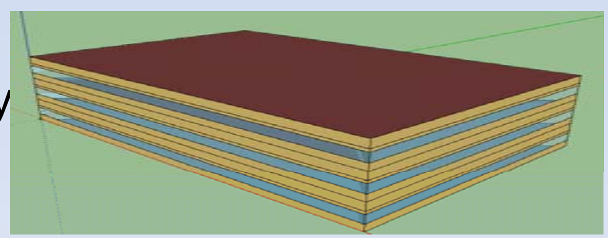
Public housing, Climate zone 6A

USA, ME Group



Dormitory, Climate zone 5B

UK, Reading University



Administrative Building,
Climate zone 4A

Building Models used by the Modeling Team

Germany, KEA
Germany, PHI

Office Building, Climate Zone 5A

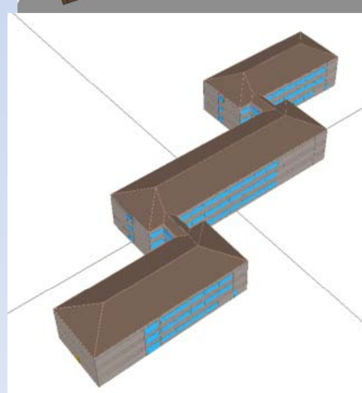
Austria, AEE

Dormitory, Climate Zones 4A and 7

Denmark, Danish Building Research Institute, SBi

School Building, Climate zone 5A

USA, NREL



Educational Building Complex, Zone 3C

Representative Climates and Locations

Country	Climate zone(s)	Representative City
Austria	4a and 7	Wien, Obertauren
China	2a, 3a, 3c, 4a, 7	Guangzhou , Shanghai, Kunming Beijing, Harbin
Denmark	5a	Copenhagen
Estonia	6a	Tartu
Germany	5a	Wurzburg
Latvia	6a	Riga
UK	4a, 5a	London, Aberdeen
USA	1a-8b	Miami, Houston, Phoenix, Memphis, El Paso, San Francisco, Baltimore, Albuquerque, Seattle, Chicago, Colorado Springs, Burlington, Helena, Duluth, Fairbanks

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)

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	0.159 (0.028)	6.3 (36)
	7	0.23 (0.041)	4.4 (25)
China	2a	0.53 (0.093)	1.9(11)
	3a	0.53 (0.093)	1.9(11)
	3c	0.53 (0.093)	1.9(11)
	4a	0.38(0.067)	2.6(15)
	7	0.30 (0.053)	3.3(19)
Denmark	5a	0.10 (0.018)	1 (57)
Estonia	6a	0.11 (0.02)	9.1 (52)
Germany	5a	0.14-0.2 (0.025-0.035)	5.0-7.1 (29-40)
Latvia	6a	0.16 (0.029)	6.3 (35)
UK	4a	0.13(0.023)	7.7 (44)
	5a	0.13(0.023)	7.7 (44)
USA	1	0.16 (0.029)	6.3 (35)
	2	0.14 (0.025)	7.1 (40)
	3	0.12 (0.022)	8.3 (45)
	4	0.12 (0.022)	8.3 (45)
	5	0.11 (0.020)	9.1 (50)
	6	0.09 (0.0167)	11.1 (60)
	7	0.09 (0.0154)	11.1 (65)
	8	0.08 (0.0133)	12.5 (75)

Windows

Country	U-value W/(m^2*K) (Btu/(hr*ft^2*°F)	R-value (m^2*K)/W (hr*ft^2*°F)/Btu	SHGC
Austria (c.z. 5A)	1.09 (0.19)	0.92 (5.3)	0.60
c.z.7	1.09 (0.19)	0.92 (5.3)	0.60
China			
c.z. 2A	2.55(0.45)	0.39 (2.2)	0.48
c.z. 3a	2.55(0.45)	0.39 (2.2)	0.48
c.z. 3C	2.70(0.48)	0.37 (2.1)	0.48
c.z. 4A	1.79(0.32)	0.56 (3.1)	0.68
c.z. 7	1.79(0.32)	0.56 (3.1)	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)	1.0 -1.3 (0.18-0.23)	0.77-1.0 (4.3-5.7)	0.55
Latvia (c.z. 6A)	1.2 (0.21)	0.83 (4.8)	0.43
UK (c.z. 4A)	1.32 (0.23)	0.76 (4.3)	0.48
c.z. 5A	1.79 (0.32)	0.56 (3.1)	0.68
USA c.z. 1&2	1.98 (< 0.35)	> 0.51 (2.9)	< 0.25
c.z. 3&4	1.70 (< 0.30)	> 0.59 (3.3)	0.30- 0.35
c.z. 5	1.53 (< 0.27)	> 0.65 (3.7)	0.35- 0.40
c.z. 6	1.36 (< 0.24)	> 0.74 (4.2)	>50
c.z. 7	1.25 (< 0.22)	> 0.80 (4.5)	>50
c.z. 8	1.02 (< 0.18)	> 0.98 (5.6)	>50

Insulation level for different wall-types (Example for c.z. 5)

Item	Component	Recommendation	
		Assembly Max	Min R-Value
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

Core Technology Bundle Compared

Passive House Institute

- Energy Target: heating < 15kWh/a (site energy), total < 120kWh/a ,
- 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

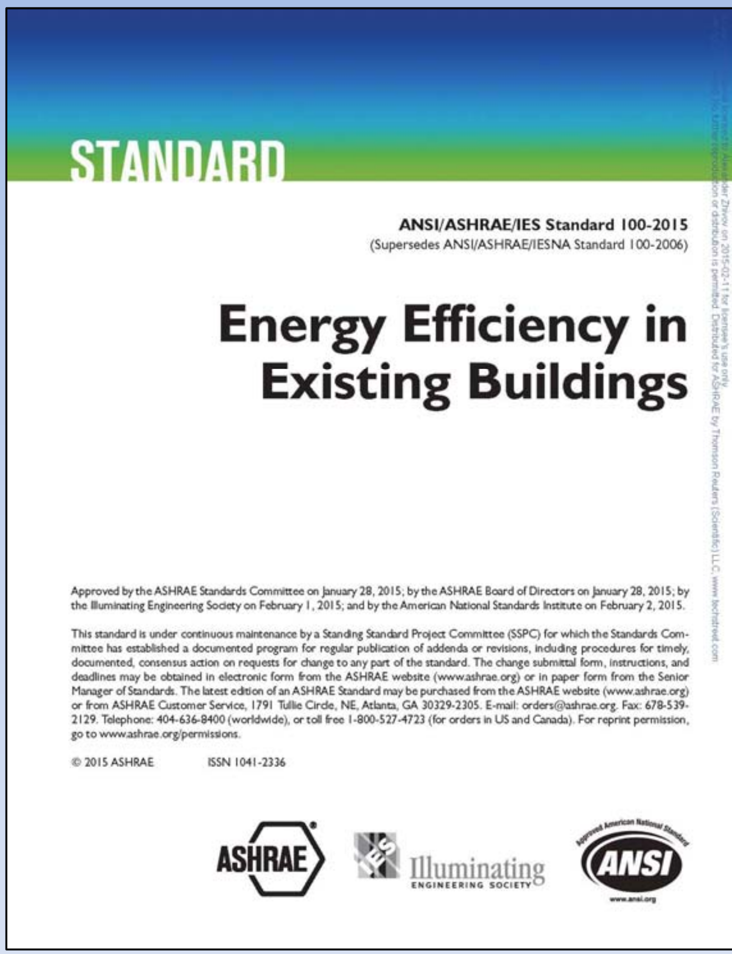
Potential for Site and Source Energy Use Reduction for DER Projects using Core Bundles of Technologies and Beyond

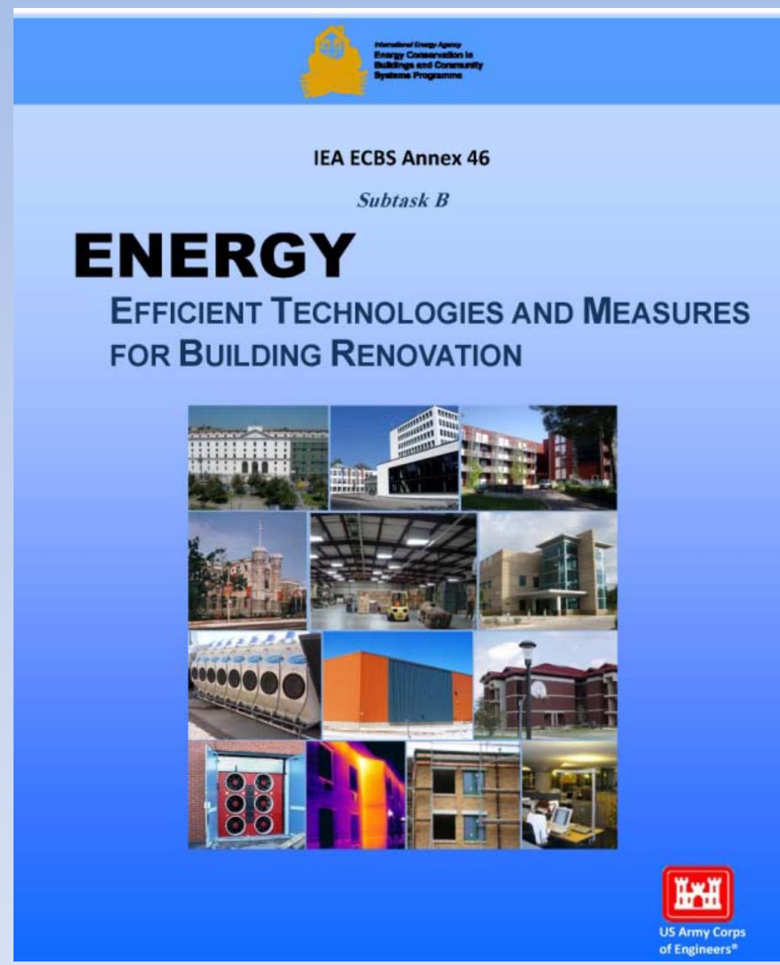
Climate Zone	Baseline			Base Case		DER			HPB	
	Total site EUI (100%) kWh/m2yr (kBtu/ft2 yr)	Site EUI for heating (100%) kWh/m2 yr (kBtu/ft2 yr)	Source EUIt, (100%) kWh/m2 yr (kBtu/ft2 yr)	Site energy use reduction, %	Source energy reduction ,%	Site energy use reduction,%	Site heating energy use reduction, %	Source energy use reduction, %	Site energy use reduction, %	Source energy reduction, %
Public Housing, Austria										
5A	218 (69)	152 (48)	210 (67)	38	31	**50**	**73**	**64**	55	68
7	253 (80)	184 (58)	235 (75)	47	36	**50**	**68**	**62**	55	68
Office Building, China										
2A	3(1)	105(33)	331(105)	37	37	**47**	**56**	**47**	54	54
3A	25(8)	119(38)	378(120)	38	38	**51**	**62**	**51**	65	65
3C	8(3)	77(24)	243(77)	36	36	**47**	**64**	**47**	69	69
4A	117(37)	201(64)	393(125)	42	42	**53**	**71**	**41**	62	55
7	239(76)	306(97)	472(150)	32	33	**50**	**62**	**38**	67	59
School Building, Denmark										
6A	252 (80)	210 (67)	314 (99)	19	16	**56**	**67**	**45**	82	63
Dormitory, Estonia										
6A	153 (49)	213 (68)	225 (71)	29	22	**47**	**69**	**37**	70	58
Office Building, Germany										
5A	256 (81)	220 (70)	307 (97)	40	27	**55**	**58**	**53**	81	76
Office Building, UK										
4A	89(28)	155(49)	291(92)	20	16	**51**	**84**	**32**	58	42
5A	135(43)	201(64)	341(108)	23	20	**60**	**83**	**42**	67	52

Potential for Site and Source Energy Use Reduction for DER Projects using Core Bundles of Technologies and Beyond

Climate Zone	Baseline			Base Case		DER			HPB	
	Total site EUI (100%) kWh/m2yr (kBtu/ft2 yr)	Site EUI for heating (100%) kWh/m2 yr (kBtu/ft2 yr)	Source EUIt, (100%) kWh/m2 yr (kBtu/ft2 yr)	Site energy use reduction, %	Source energy reduction ,%	Site energy use reduction,%	Site heating energy use reduction, %	Source energy use reduction, %	Site energy use reduction, %	Source energy reduction, %
Barracks, USA										
1A	1 (0)	398 (126)	1154 (366)	17	19	**39**	**59**	**42**	59	59
2A	33 (10)	380 (121)	1025 (325)	17	18	**41**	**84**	**42**	60	59
2B	17(5)	365 (116)	1008 (320)	17	18	**40**	**80**	**42**	61	61
3A	65 (21)	394 (125)	965 (306)	19	18	**45**	**84**	**42**	63	59
3B	37 (12)	326 (103)	812 (258)	15	14	**39**	**82**	**37**	60	57
3C	35 (11)	273 (87)	634 (201)	12	9	**33**	**70**	**31**	46	37
4A	103 (33)	397 (126)	869 (276)	20	16	**48**	**85**	**25**	65	59
4B	86 (27)	333 (106)	745 (236)	16	12	**42**	**88**	**35**	62	56
4C	111 (35)	330 (105)	678 (215)	18	12	**44**	**86**	**35**	62	55
5A	160 (51)	422 (134)	872 (277)	21	17	**51**	**87**	**42**	67	60
5B	133 (42)	362 (115)	733 (233)	18	13	**52**	**88**	**37**	65	57
6A	212 (67)	448 (142)	839 (266)	22	16	**55**	**88**	**44**	70	61
6B	192 (61)	414 (131)	773 (245)	21	14	**53**	**89**	**41**	69	60
7	283 (90)	508 (161)	878 (279)	24	18	**59**	**88**	**47**	73	63
8	417 (132)	630 (200)	978 (310)	24	18	**64**	**92**	**52**	77	67
Office Building, USA										
1A	24(7)	261 (83)	815 (259)	30	27	**48**	**91**	**45**	66	64
2A	60 (19)	285 (90)	814 (258)	32	28	**46**	**63**	**43**	70	65
2B	81 (26)	314 (100)	862 (273)	36	29	**49**	**87**	**41**	73	91
3A	82 (26)	288 (91)	771 (245)	34	28	**47**	**63**	**43**	71	64
3B	68 (22)	251 (80)	680 (216)	30	23	**51**	**92**	**41**	66	58
3C	45 (14)	183 (58)	507 (161)	26	16	**41**	**96**	**30**	59	51
4A	96 (30)	271 (86)	685 (217)	35	26	**50**	**89**	**38**	69	60
4B	71 (22)	227 (72)	593 (188)	31	21	**50**	**95**	**37**	63	54
4C	76 (24)	206 (65)	513 (163)	31	18	**48**	**96**	**33**	63	52
5A	107 (34)	270 (86)	656 (208)	35	25	**50**	**87**	**37**	69	58

+ more than 400 other EEMs

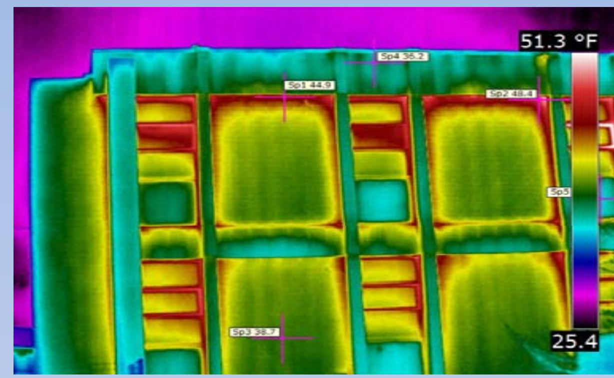


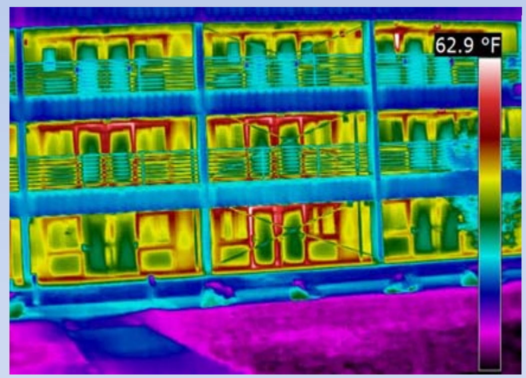


Annex 61 DER Guide - Outline

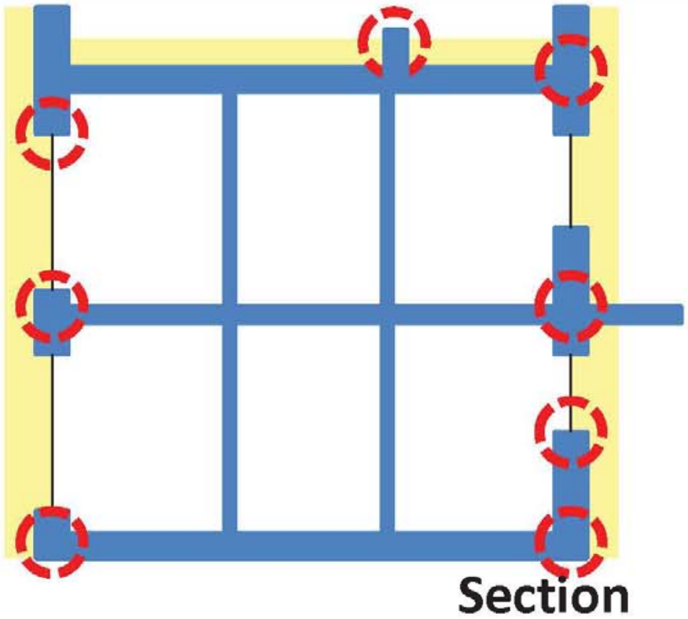
- **Introduction**
- **What is Deep Energy Retrofit**
- **Energy efficiency technologies and strategies**
- **Core technologies for DER**
- **Building Envelope**
  - Wall and roof cross-sections
  - Insulation types and levels for different climate conditions
  - Thermal Bridges
  - Window types and 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**

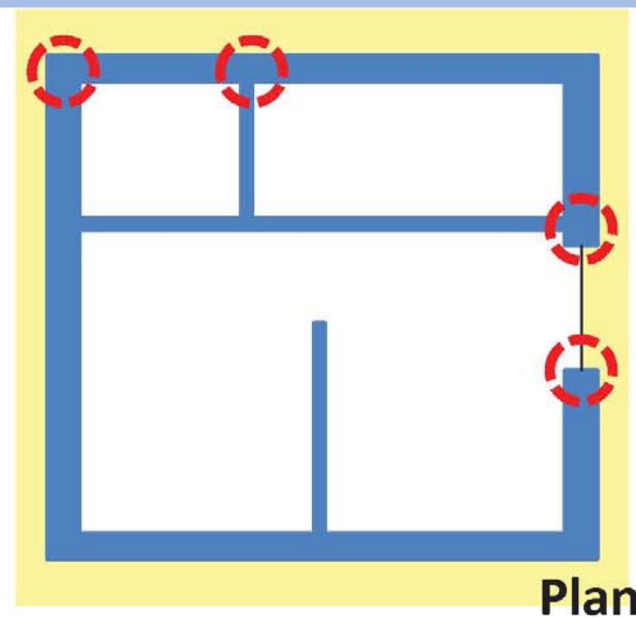
Examples of Thermal Bridges: Parapets, doors, slabs





Thermal Bridges

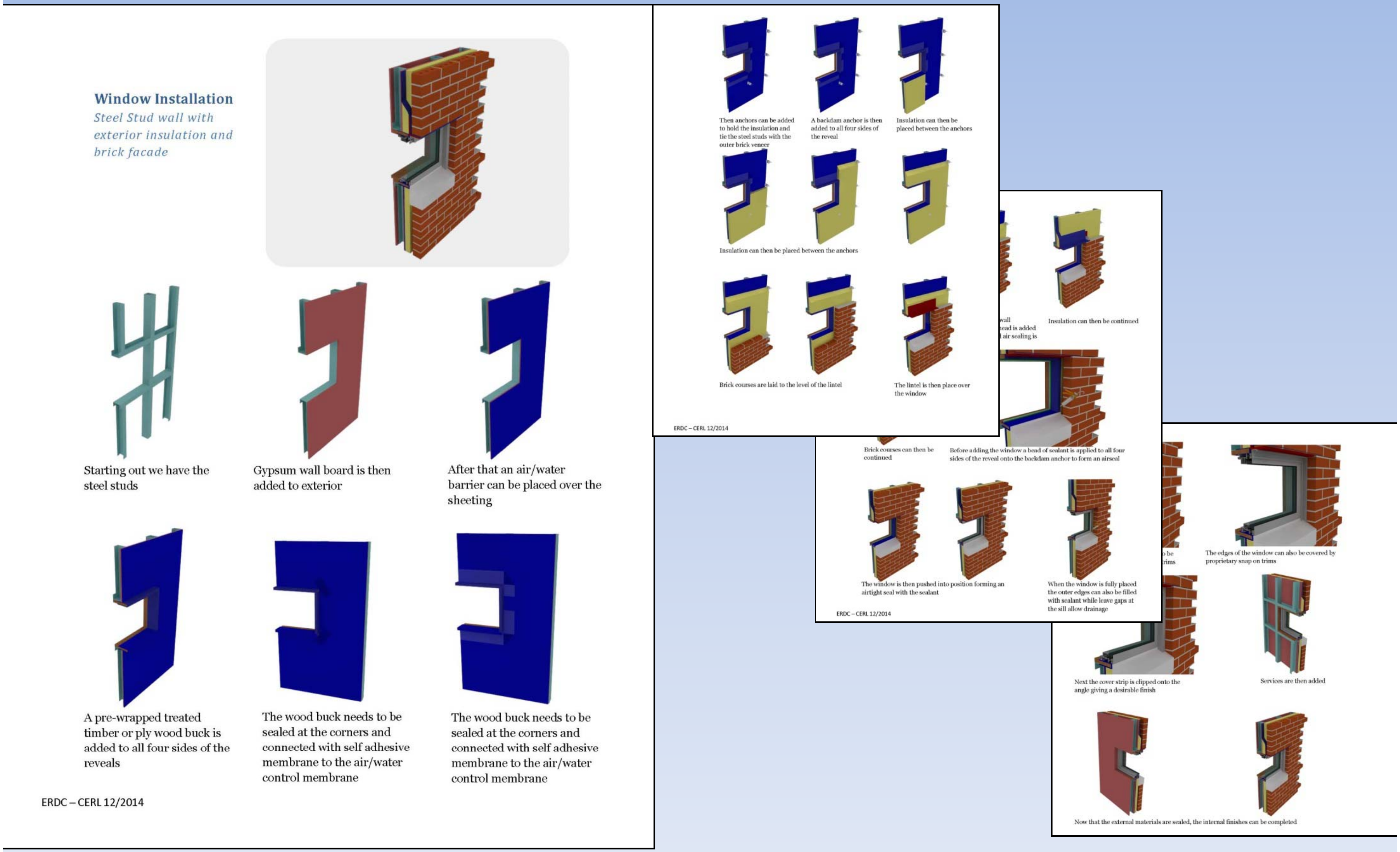




Details of Major Magnitude
1. At Eaves/Ridge
2. Window and Door Fitting – Head, Sill and Jamb
3. At Projections, Shades Or Intermediate Floors
4. Internal Walls to External Walls
5. Intermediate Floors
6. At Grade

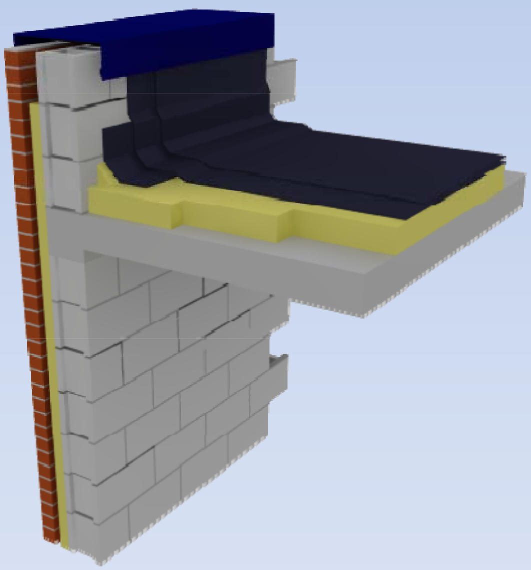
Details of Minor Magnitude
1. Wall Corner – Never Usually an Issue
2. Threshold or Door
3. Duct and Service Connections
4. Penetrations at Installations in Roof; PV or Water Tanks

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

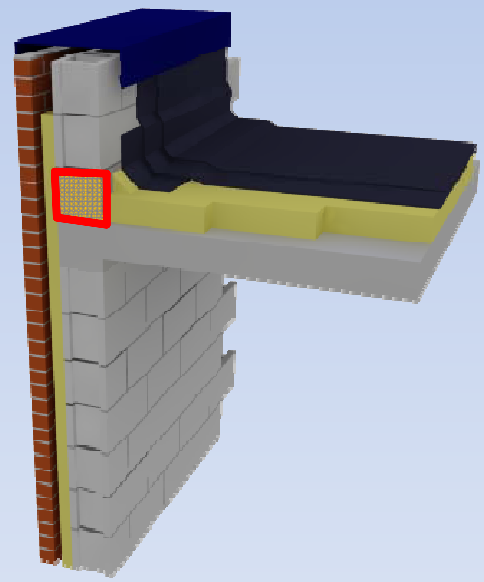


Thermal Bridge Mitigation

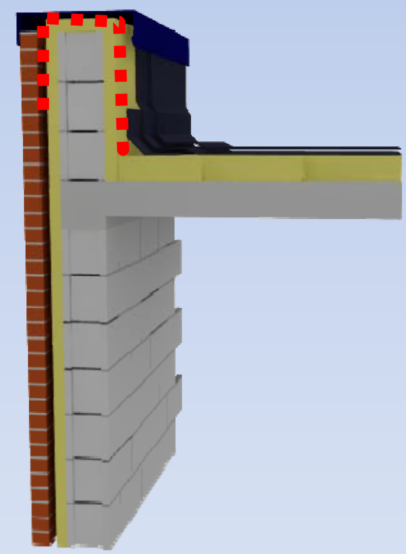
Typical detail poor thermal bridge



Insert thermal break



Wrap the parapet

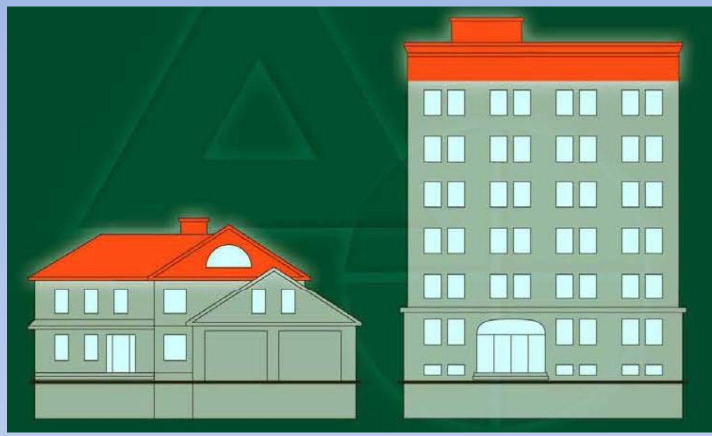


Building Air Tightness

Country	Source	Requirement	cfm/ft² @ 75Pa
Estonia	Ordinance No. 58. RT I, 09.06.2015, 21, 2015	≤6 m³/(h·m²) @ 50Pa - renovation ≤3 m³/(h·m²) @ 50Pa - new construction	0.42 0.21
Austria	OIB RL 6, 2011 for buildings with mechanical ventilation	1.5 1/h at 50 Pa	0.28
Denmark	Danish Building Regulations BR10 [48]	1.5 1/h at 50 Pa	0.28
Germany	DIN 4108-2	1.5 1/h at 50 Pa	0.28
USA	USACE ECB for all buildings [21], ASHRAE Standard 189.1-2011, 2013 Supplement, ASHRAE Standard 189.1.–2013 Supplement, ASHRAE Standard 90.1 - 2013		0.25
	USACE HP Buildings and DER proposed requirement		0.15
Latvia	Latvian Construction Standard LBN 002-01 for buildings with mechanical ventilation	2 m³/(m²h) at 50 Pa	0.14
UK	TS-1Commercial Tight	2 m³/h/m² 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.

Sealing the Building Envelope



- Top
- Bottom
- Vertical Shafts
- Outside Walls
- Compartmentalize

Lighting – Improved Design and Technology

Lighting Design Guide for Low Energy Buildings – New and Retrofits

Optimal 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

Advanced HVAC Systems

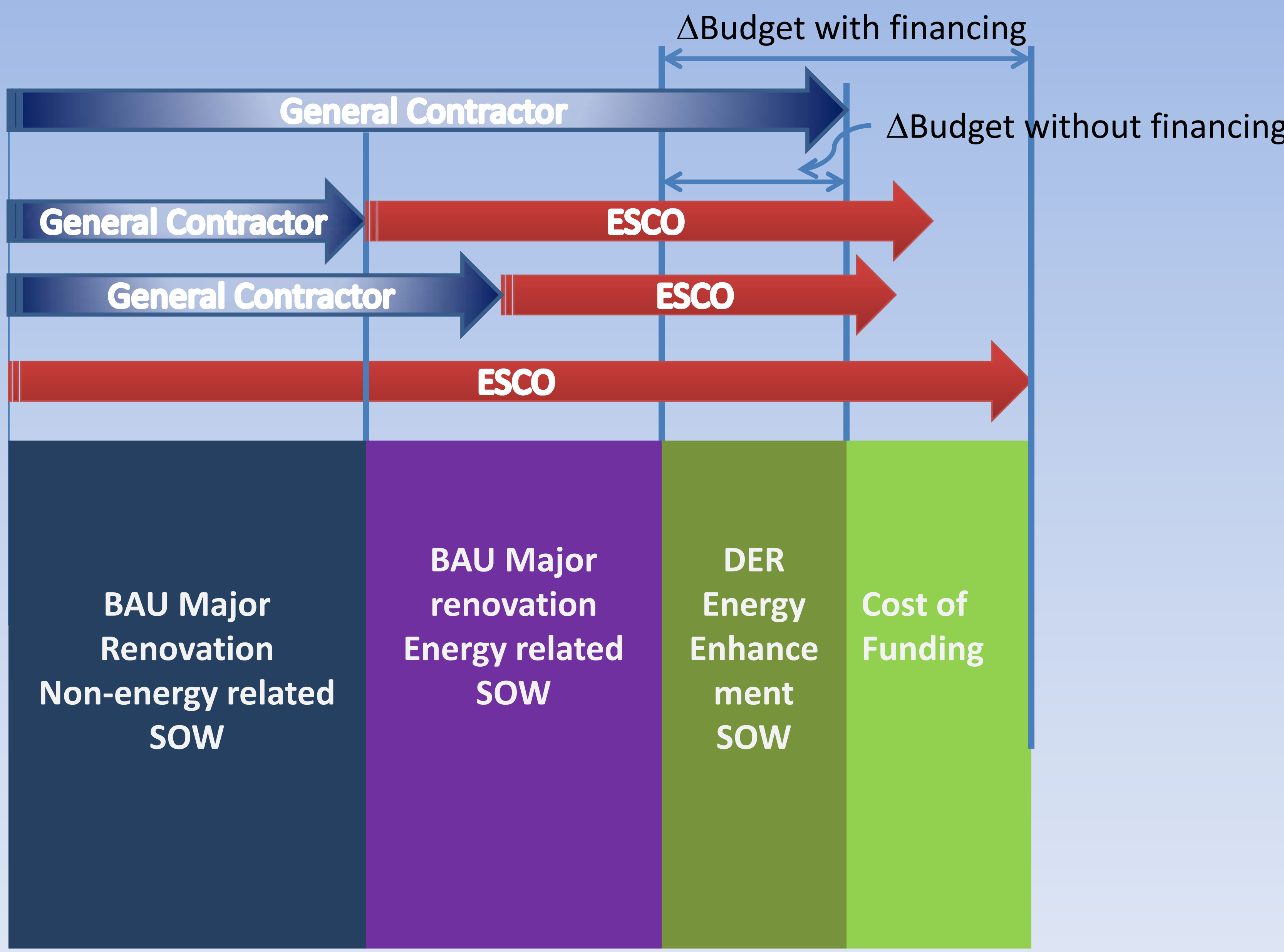
- Dedicated outdoor air system (DOAS)
- Heating and Cooling equipment per current national standard
- Heat recovery (sensible and latent)
- Duct air tightness – class C
- Hot and chilled water pipes insulation per current national standard

Country	HVAC Standard
Austria	EN 1507, EN 12237 ÖNORM H 5057, OIB RL 6, 2011
China	GB 50243-2002 GB50736-2012 GB50198-2005
Denmark	Standard 447 Standard 452
Estonia	EVS-EN 13779, EN 12237 Ordinance No. 70. RT I, 09.11.2012, 12
Germany	EnEV 2014, DIN V 18599- 2 and 7 DIN 1946- 6, DIN EN 13779 DIN 24192 II/III/IV DIN 4108- 6, DIN 4701- 10, EnEV 2009/2014
Latvia	Latvian Construction Standard LBN 231-03 Latvian Construction Standard LBN 003-01
UK	BS EN 15727:2010 BS 5422:2009 Non-Domestic Building Services Compliance Guide:2013
USA	ASHRAE Std 90.1 2010

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.

DER Implementation Strategies



Allowable (Cost Effective) Budget Increase for DER

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

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

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

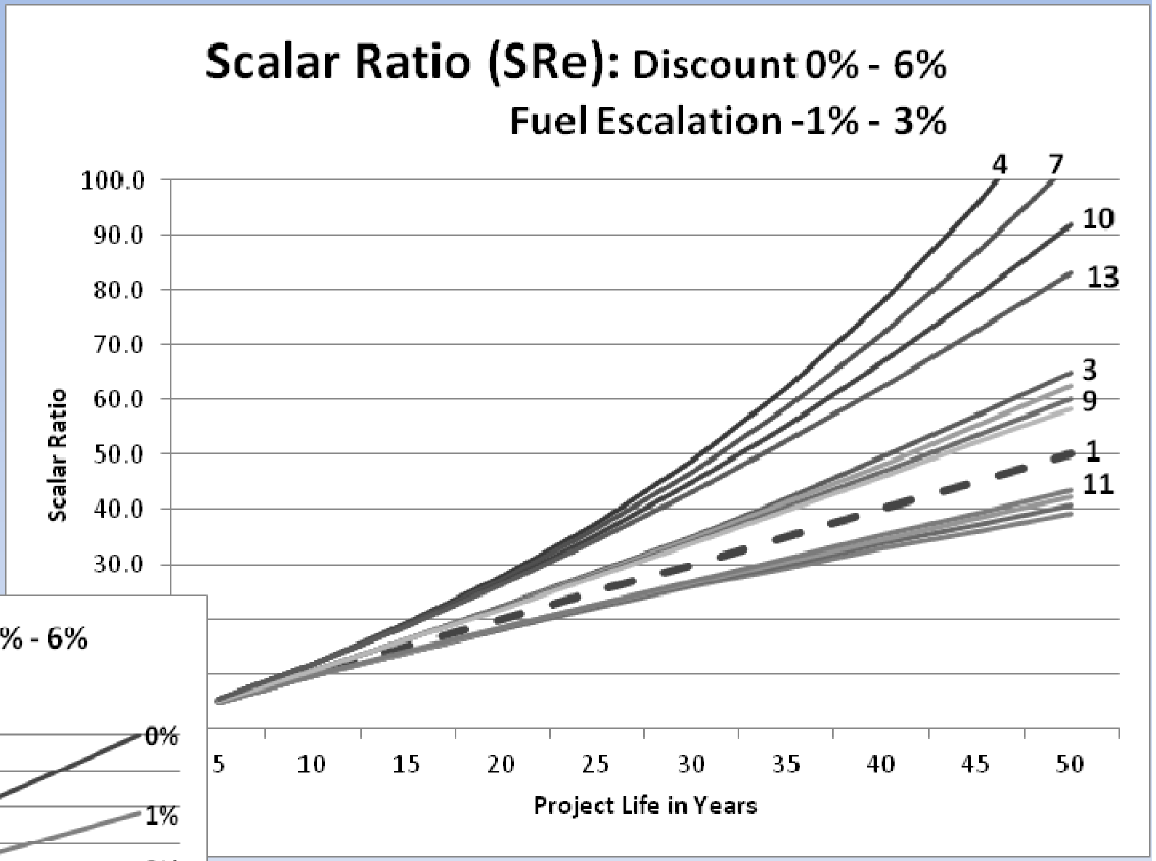
S_M and S_L scalars can be calculated and are the uniform present worth factor series that use the discount rate, the same way as SR_E with the escalation rate e=0%.

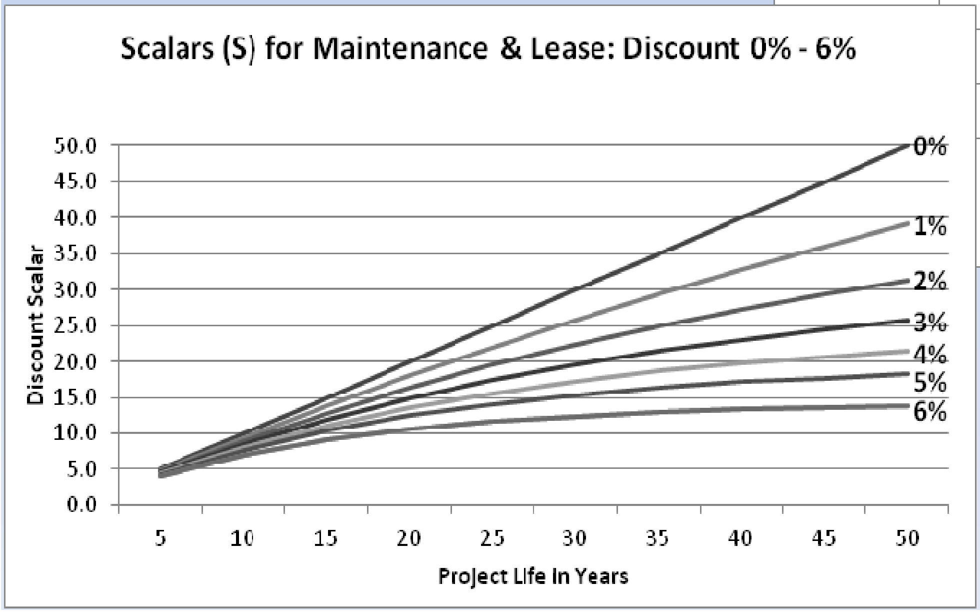
NPV = Net Present Value function
N = study life in years
d = discount rate
e –escalation rate

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

No.*	Economic Life (yrs)											
	Discount	Escalation	5	10	15	20	25	30	35	40	45	50
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.





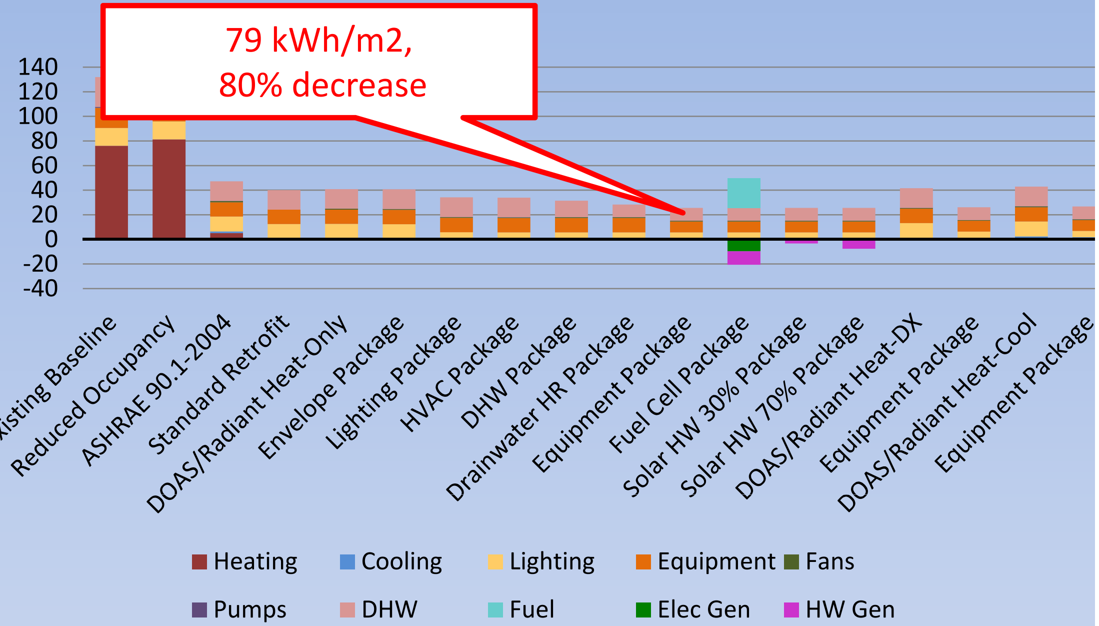
DER Technical Guide areas of concern – help needed

- Windows and their installation
- Insulation types and installation techniques
- Vapor Barrier: examples of good practices
- Air Barrier: good and bad practices
- Quality Assurance
- HVAC technologies

DER Business Guide - help needed

- Financial aspects of LLC
  - Maintenance costs
  - Insurance Costs
  - Lease/rent rates and rentability
- Legal background for EPCs in different countries
- Business Models
- Risks associated with DER and their mitigation

DER Current Ongoing Projects – lessons learned



Questions, comments??