Annex 61 Business and Technical Concepts for Deep Energy Retrofits of Public Buildings

Deep Energy Retrofit of Buildings Forum

Sponsored by the Federal Facilities Council of the National Academies of Sciences, Engineering, and Medicine

In partnership with:

International Energy Agency
Secure Sustainable Together

EBC Energy in Buildings and Communities Programme

US Army Corps of Engineers

ASHRAE

U.S. DEPARTMENT OF ENERGY

GSA

September 15-16, 2016
Washington, DC

Why DER?

- 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% of the total buildings floor area p.a., USA: 3% p.a. site energy reduction compared to CBECS 2003 through 2015 and 2.5% between 2015 and 2025)

Typical Energy Efficiency Improvement Projects

- A part of major building renovation
- A part of minor building renovation
- Utilities modernization projects
- System retro/ongoing commissioning
- Dedicated energy projects using ESPC or UESC contracts
- Mechanical and electrical equipment/systems replacement

Reasons for major renovation

- ***Extension of the useful building life*** requiring overhaul of its structure, internal partitions and systems;
- ***Repurposing of the building***, e.g., renovation of old warehouses into luxury apartments (Soho area in New York, NY, or into boutique shops in Montreal, QC), or renovation of old Army barracks into offices);
- Bringing the building ***to compliance with new or updated codes***;
- ***Remediation of environmental problems*** (mold and mildew) and improvement of the visual and thermal comfort and indoor air quality,
- ***Adding the value*** to increase investment (increasing useful space and/or space attractiveness/quality) ***resulting in a higher sell or lease price***.

Major Renovation: Business as Usual

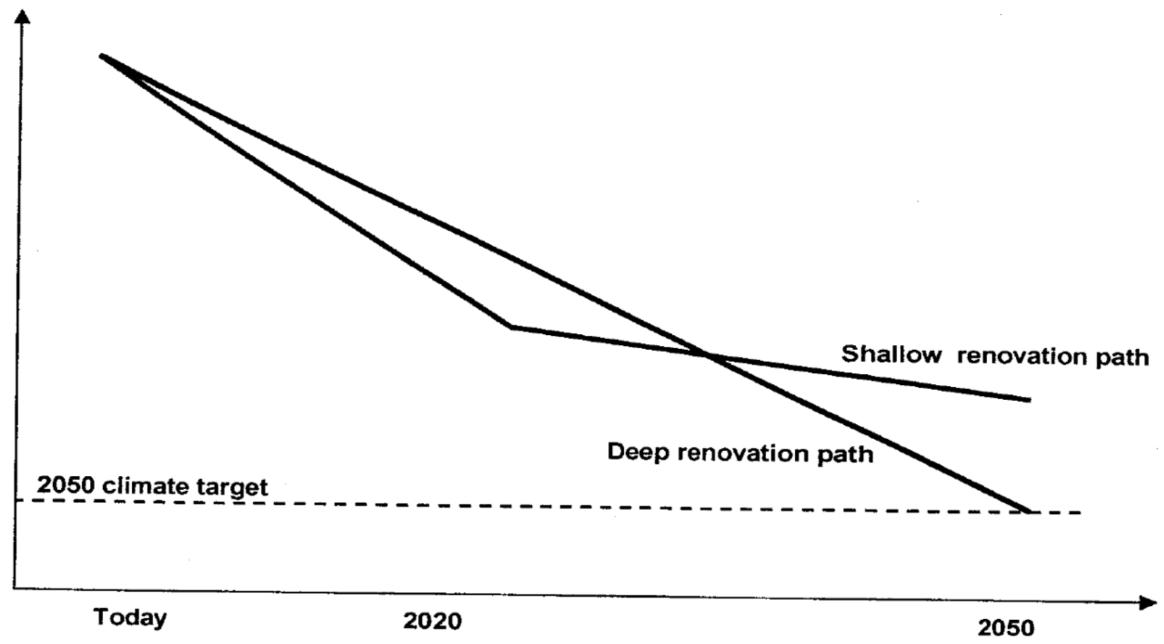
Examples of calculated % of energy use reduction (including plug-loads) with major renovation projects from pre-1980 baseline to current minimum energy standards

- 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%**

Timing a DER to Coincide with a Major Renovation

- Building is typically evacuated and gutted;
- Scaffolding is installed;
- Single pane and damaged windows are scheduled for replacement;
- Building envelope insulation is replaced and/or upgraded;
- Most of mechanical, electrical lighting, and energy conversion systems will be replaced
- ***A significant sum of money covering the cost of energy-related scope of the renovation designed to meet minimum energy code is already budgeted anyway.***

How to Meet Energy Goals?

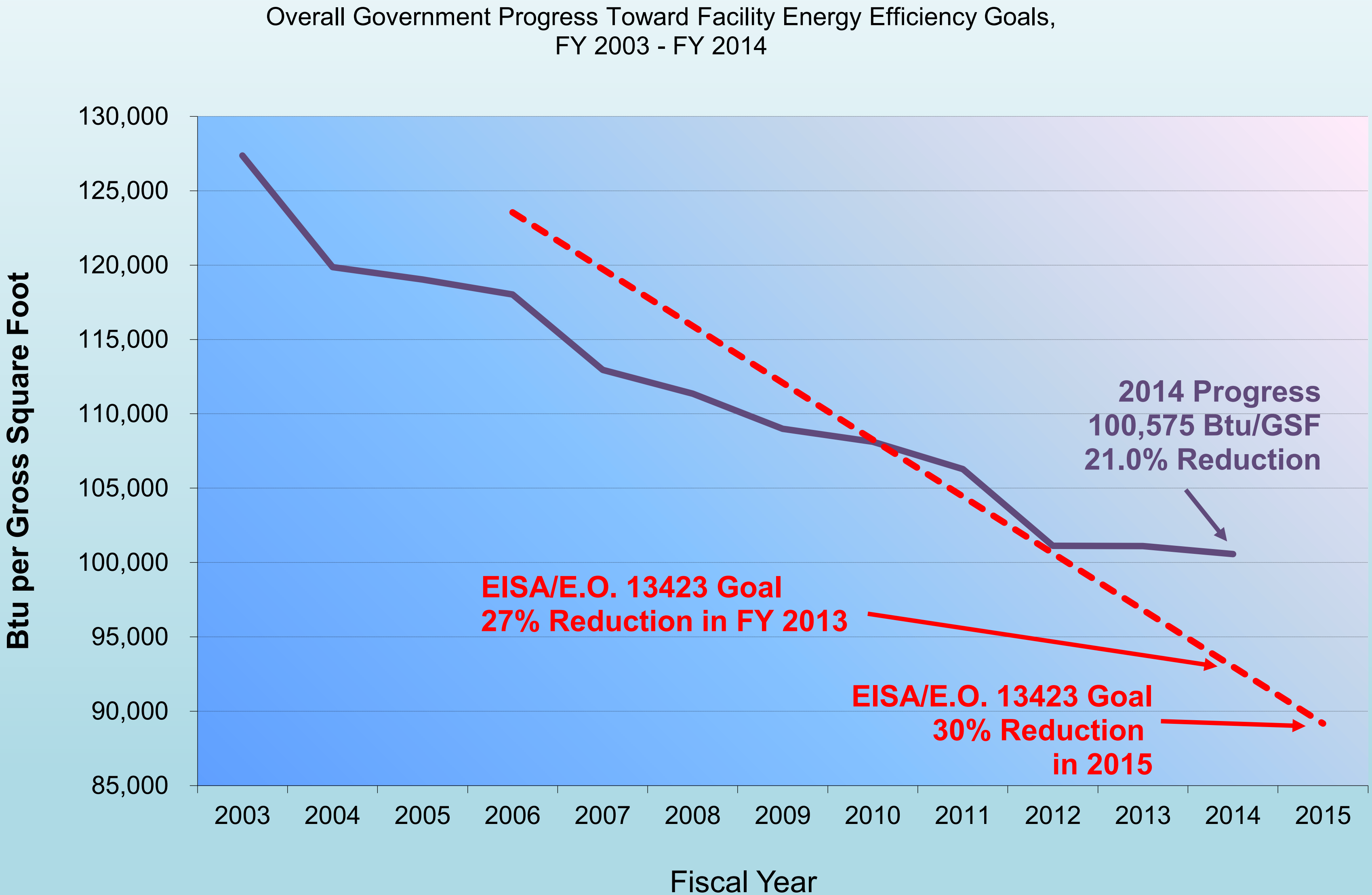


The speed trap of shallow renovation (from "Economics of Deep Renovation," *Ecofys* 2011

Spending available annual budgets for many cheaper shallow renovations Vs fewer, more expansive deep energy renovations may lead to unwanted, irreversible long-term consequences.

Looks better for short-term decisions, but may well fail to achieve long-term energy goals.

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



PRELIMINARY DATA

Annex 61 Business and Technical Concepts for Deep Energy Retrofits of Public Buildings

www.iea-annex61.org

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

Annex 61 team

- **Austria** – AEE
- **Belgium** – Factor 4
- **China** - Chongqing University
- **Denmark**:
  - Danish Building Research Institute, Aalborg University Copenhagen
  - Cenergia Energy Consultants
- **Estonia:**
  - Tallinn University of Technology
  - University of Tartu
- **Finland** – VTT
- **Germany:**
  - KEA
  - Institute for Housing and Environment
  - PHI
  - Energetic Solutions
- **Ireland** – PHA
- **Latvia** - Riga Technical University
- **The Netherlands** – KAW
- **UK**
  - Reading University
  - SPIE
- **USA**
  - US Army (ERDC/CERL, USACE, POM AG)
  - DOE FEMP
  - GSA
  - RMI
  - NBI
  - ME Group
  - Honeywell International
  - Morrison Hershfield
  - Anis Building Enclosure Consulting
  - Camroden

Annex 61 Structure, Objectives and Deliverables

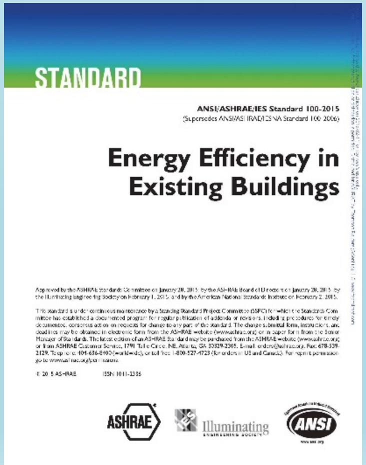
Operating Agents: Dr. Alexander Zhivov (USA) and Mr Rüdiger Lohse (DE)		
Subtasks	**Objectives**	**Deliverables**
Subtask A Co-leads: Dr. Ove Mørck, DK Dr. A. Zhivov, USA	Prepare and evaluate case studies of existing DER concepts. Develop a guide for achieving financially attractive DERs of buildings and building communities.	***DER – Case Studies*** ***DER – Technical Guide***
Subtask B Co-leads: Mr. Rüdiger Lohse, DE Mr. John Shonder, USA Mr. Cyrus Nasseri, USA	Develop business models for DER/refurbishment of buildings and building groups using combined government/public and private funding	***DER – Business and Financial Guide***
Subtask C Leader: Mr. Cyrus Nasseri, USA	Demonstrate Selected Deep Energy Retrofit Concepts using combined government/public and private funding, and prepare case studies.	***DER – Report on Case Studies***
Subtask D Co-leads: Mr. Rüdiger Lohse, DE Mr. Heimo Staller, AT	Develop an IT-tool for Decision Makers and ESCOs	***Web-based IT-tool kit***

Annex 61 Scope

- Buildings with low internal loads (e.g., offices, barracks, dormitories, public housing, educational buildings, **undergoing MAJOR RENOVATIONS**
- Historic/listed buildings **are excluded**
- Buildings with high internal loads (e.g., dining facilities, hospitals, data centers) **are excluded**

USA

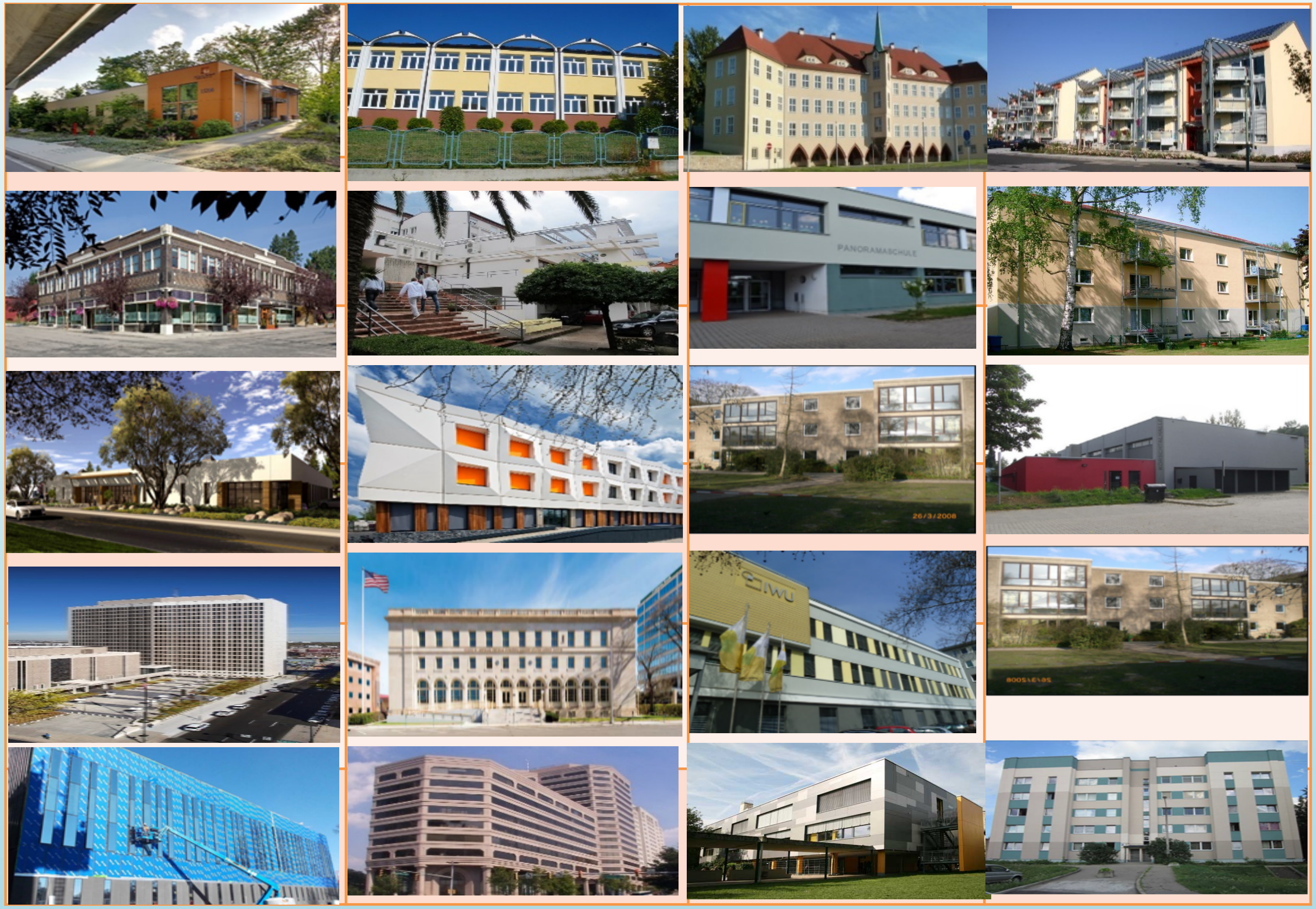
- **UFC 1-200-02** “High Performance and Sustainable Buildings: For new construction and major renovation Energy Efficiency requirement is to perform 30% better than ASHRAE 90.1-2007. Army gives an option to alternatively do 12% better than 90.1-2010
- **ASHRAE Standard 90.1 Scope**: ….new portions of the building (existing), new systems and equipment in existing building**…doesn’t apply to major renovation** of existing buildings.
- Major renovation **is not a part of the 10 CFR 433** “ENERGY EFFICIENCY STANDARDS FOR NEW FEDERAL COMMERCIAL AND MULTI-FAMILY HIGH-RISE RESIDENTIAL BUILDINGS”
- New ASHRAE Standard 100-2015: EUI targets for 53 building categories, are based on top 25% of the exiting building stock per CBECS 2003.



EU Energy Performance of Buildings Directive (EPBD 2010)

- Member States shall develop policies to stimulate the transformation of buildings to be <u>refurbished to a nearly zero-energy condition.</u>
- A nearly zero-energy building is defined as "*a building that has a very high energy performance. ….*"
- 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."

Deep Energy Retrofit - Case Studies



26 well documented case studies from Austria, Denmark, Estonia, Germany, Ireland, Montenegro, The Netherlands and the USA.

Definition of DER

Annex 61 team has collected and documented 26 case studies from Austria, Denmark, Estonia, Germany, Ireland, Montenegro, The Netherlands and the USA in which site energy has been reduced by 50% or better.

Based on anaysis of trends in policies from around the world and best practices including those, documented in case-studies, IEA EBC Annex 61 team has proposed the following definition of the Deep Energy Retrofit:

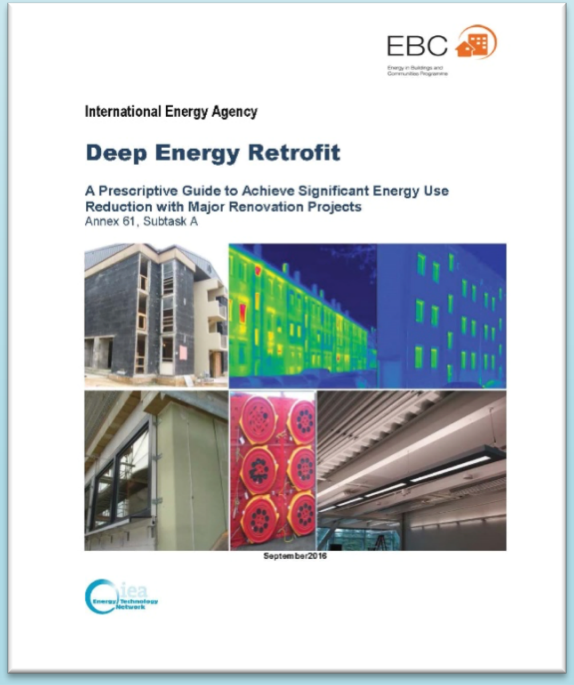
Deep Energy Retrofit (DER) is a major building renovation project in which site energy use intensity (including plug loads) has been reduced by at least 50% from the pre-renovation baseline with a corresponding improvement in indoor environmental quality and comfort.

Core Technologies Bundle

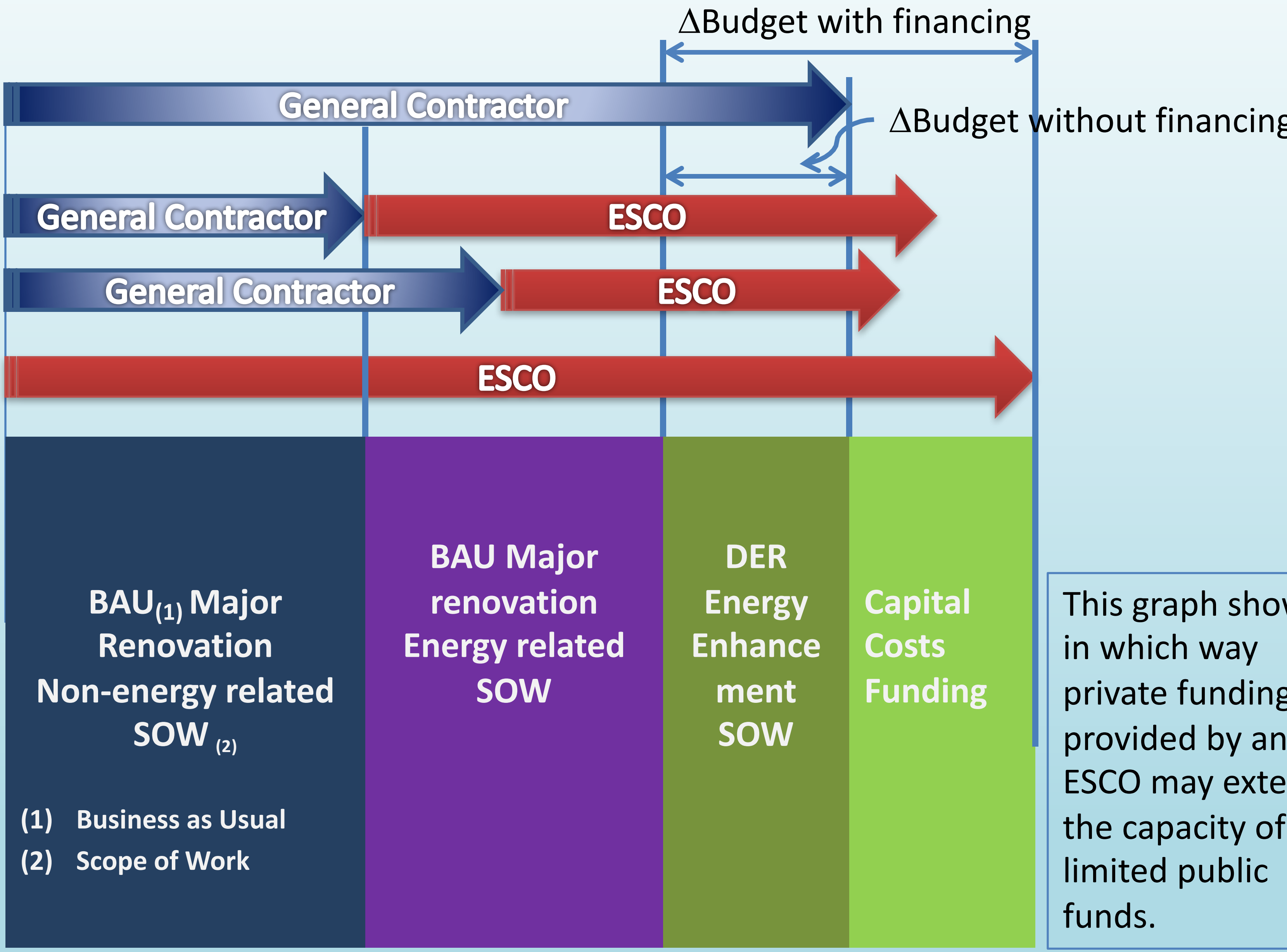
Category	Name	Specification
Building Envelope	Roof insulation	Level defined through modeling
	Wall insulation	Level defined through modeling
	Slab Insulation	Level defined through modeling
	Windows	Parameters defined through modeling
	Doors	National Standards
	Thermal bridges remediation	Guide, main text and Appendix D
	Air tightness	0.15 cfm/ft2 (for USA)
	Vapor Control	Guide, main text
	QA	Guide, Appendix J
Lighting and Electrical Systems	Lighting design , technologies and controls	Guide, Appendix G
	Advanced plug loads, smart power strips and process equipment	TopTen (Europe), Top Tier EnergyStar, FEMP Designated, etc
HVAC	High performance motors, fans, furnaces, chillers, boilers, etc	ASHRAE Std 90.1 2013 and EPBD
	DOAS	Guide, main text
	HR (dry and wet)	Guide, main text
	Duct insulation	EPBD requirements
	Duct airtightness	ASHRAE Handbook and EPBD requirements (Class C ductwork)
	Pipe insulation	EPBD requirements

DER Technical Guide Objectives

- Provide guidance on **core technologies bundle** for DER focusing on building envelope ECMs, lighting systems, HVAC systems efficiency
- **Technology Characteristics** (e.g., U-values, building and duct air tightness, illumination levels and LPD, etc.)
- **Critical design, construction requirements and recommendations** (how-to and how-not-to)
- **Important architectural details and pictures** for
  - Wall cross-sections
  - BE elements connections
  - Continuous air barrier
  - Vapor Control
  - Thermal bridge remediation
- **Outline Quality Assurance Process**
- **How to make DER Economics work?**



DER Implementation Strategies



This graph shows in which way private funding provided by an ESCO may extend the capacity of limited public funds.

Maximum (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

Pilot DER Projects

GSA NDERP – St. Croix, US Virgin Islands and Silver Spring/New Carrollton

Denmark: Grønne Etablissementer – Almegårds Kaserner

Kindergarten in Valga, Estonia

IWU office building, Darmstadt, Germany

Barracks 630 at the Presidio of Monterey

Expectations for the Forum

- To share the progress and preliminary results of the IEA EBC Program Annex 61
- To learn, how U.S. Federal Agency and building owners are planning to adapt DER to meet national energy goals
- To share the results of analysis and lessons learned from Case Studies and Pilot Projects with DER
- To discuss technical aspects of DER and find volunteers to review the DER Technical Guide
- To discuss Business and Financial models for DER in Public Buildings, their applicability and limitations
- To understand challenges and roadblocks for broad implementation of DER and identify ways to overcome them

Questions?

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