Energy Exchange

Federal Sustainability for the Next Decade

U.S. Department of Energy

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

Dr. Alexander Zhivov
US Army Engineer Research and Development Center
Mr. Ruediger Lohse
Climate Protection and Energy Agency of Baden Wurtenberg, Germany
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There are different reasons why countries care about energy efficiency?

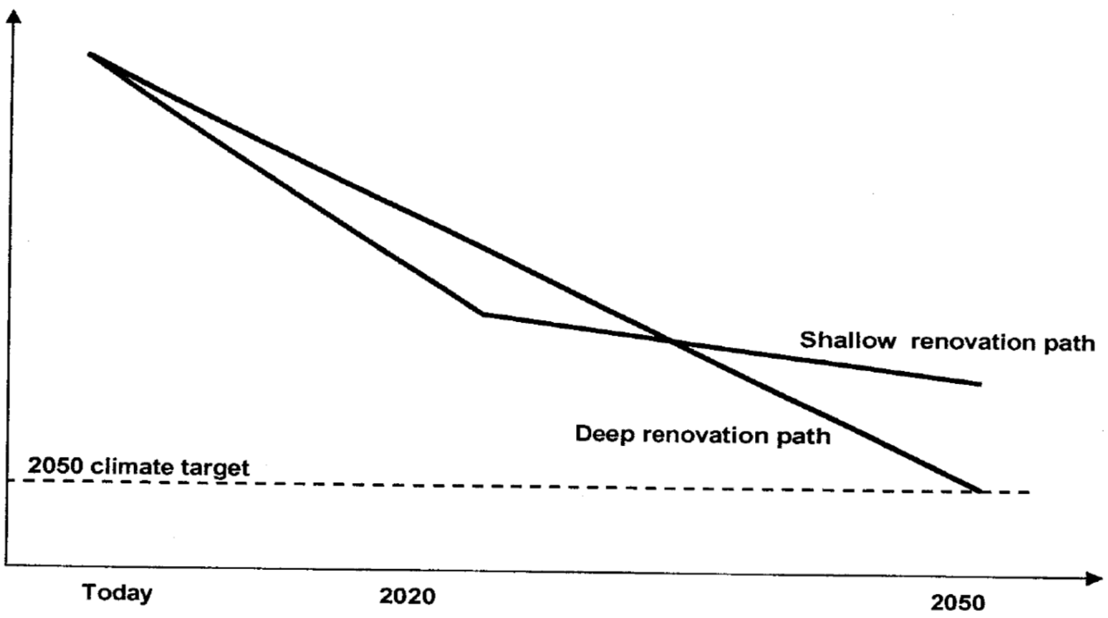
- The effects of global climate change
- Energy cost
- Energy security
- Independence from fossil fuel imports

Whatever the drivers are, they stimulate many countries and their communities to set ambitious goals to reduce energy use and to increase the relative amount of energy derived from renewable energy sources.

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)

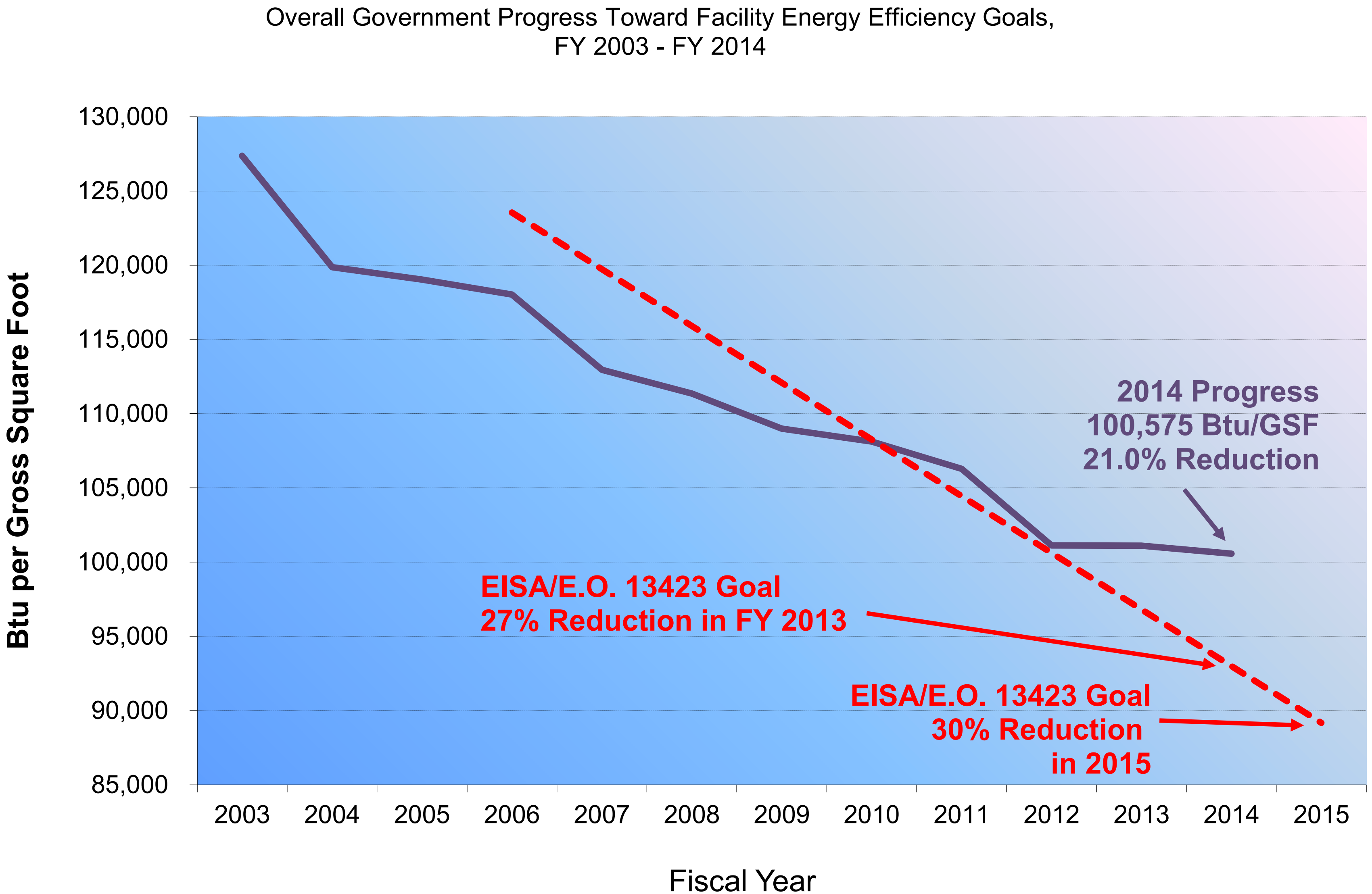
How to Meet Energy Goals?



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.

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



PRELIMINARY DATA

Annex 61

Business and Technical Concepts for Deep Energy Retrofit of Public Buildings

EBC
Energy in Buildings and Communities Programme

Deep Energy Retrofit (IT-Tool)

Annex 61 Objectives

- To provide a framework and selected tools and guidelines to significantly reduce energy use (by more than 50%) *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/refurbishing 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.

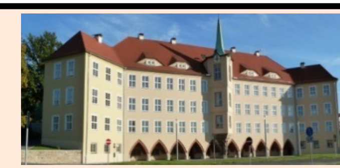
EU Energy Performance of Buildings Directive (EPBD 2010)

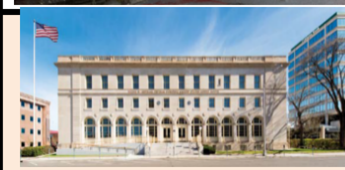
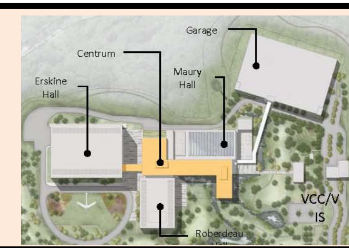
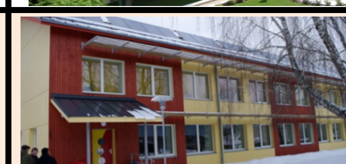
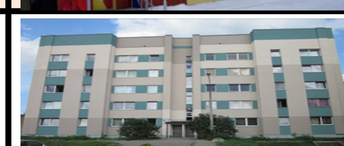
- Member States shall develop policies and take measures such as setting targets to stimulate the transformation of buildings to be refurbished to a nearly zero-energy condition.
- A Member State shall not be required to set minimum energy performance requirements that are not cost-effective over a building's 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."

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.

Annex 61 DER Case Studies

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	

Typical Energy Efficiency Improvement Projects

- As a part of major building renovation*
- As a part of minor building renovation
- Utilities modernization projects
- During mechanical and electrical equipment/systems replacement
- System retro commissioning
- Dedicated energy projects using ESPC or UESC contracts

Note: The U.S. Department of Energy (DOE) (DOE 2010) and EPBD (EU 2010) define a major building renovation as any renovation where the cost exceeds 25% of the replacement value of the building. EPBD also defines building renovation as a major renovation if more than 25% of the surface of building envelope undergoing renovation

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: 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**%

Typical energy savings using ESCOs are 20 to 50%

"Core Technology" Bundle for DER

Category	Name
Building Envelope	Roof insulation
	Wall insulation
	Slab Insulation
	Advanced Windows
	Insulated Doors, Vestibules
	Thermal bridges remediation
	Air tightness
	Water/Vapor Barriers
	BE Quality Assurance
Lighting and Electrical Systems	Lighting design and efficient technologies and controls, efficient motors, VFD drives
HVAC	Smaller sized High performance fans, furnaces, chillers, boilers, etc.
	DOAS
	HR (dry and wet)
	Duct insulation
	Duct air tightness
	Pipe insulation

Advanced Quality Assurance Process

- 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.

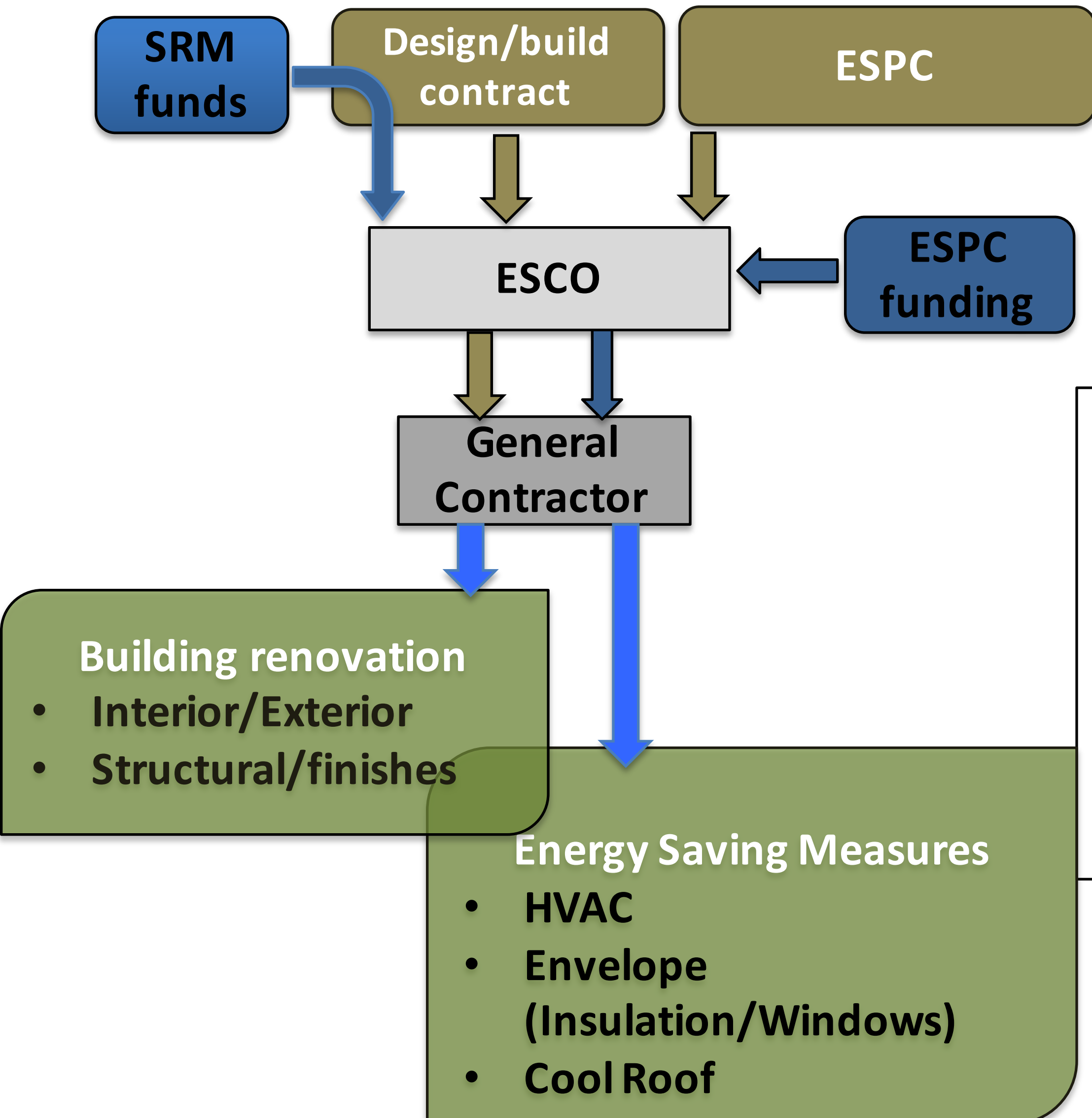
Major Renovation is the Best Time for DER

- The building is typically evacuated and becomes gutted;
- Scaffolding is installed;
- Single-pane and damaged windows are often scheduled for replacement;
- Building envelope insulation is considered; and
- Most of mechanical, electrical lighting, and energy conversion systems (e.g., boiler and chillers), and connecting ducts, pipes, and wires will be replaced anyway.
- A significant sum of money is budgeted (programmed) to cover the cost of the construction and of the energy-related scope of the renovation to be designed to meet minimum energy code requirements.
- These funds may be applied to implement advanced energy retrofit design.

DER Funding and Implementation Strategy

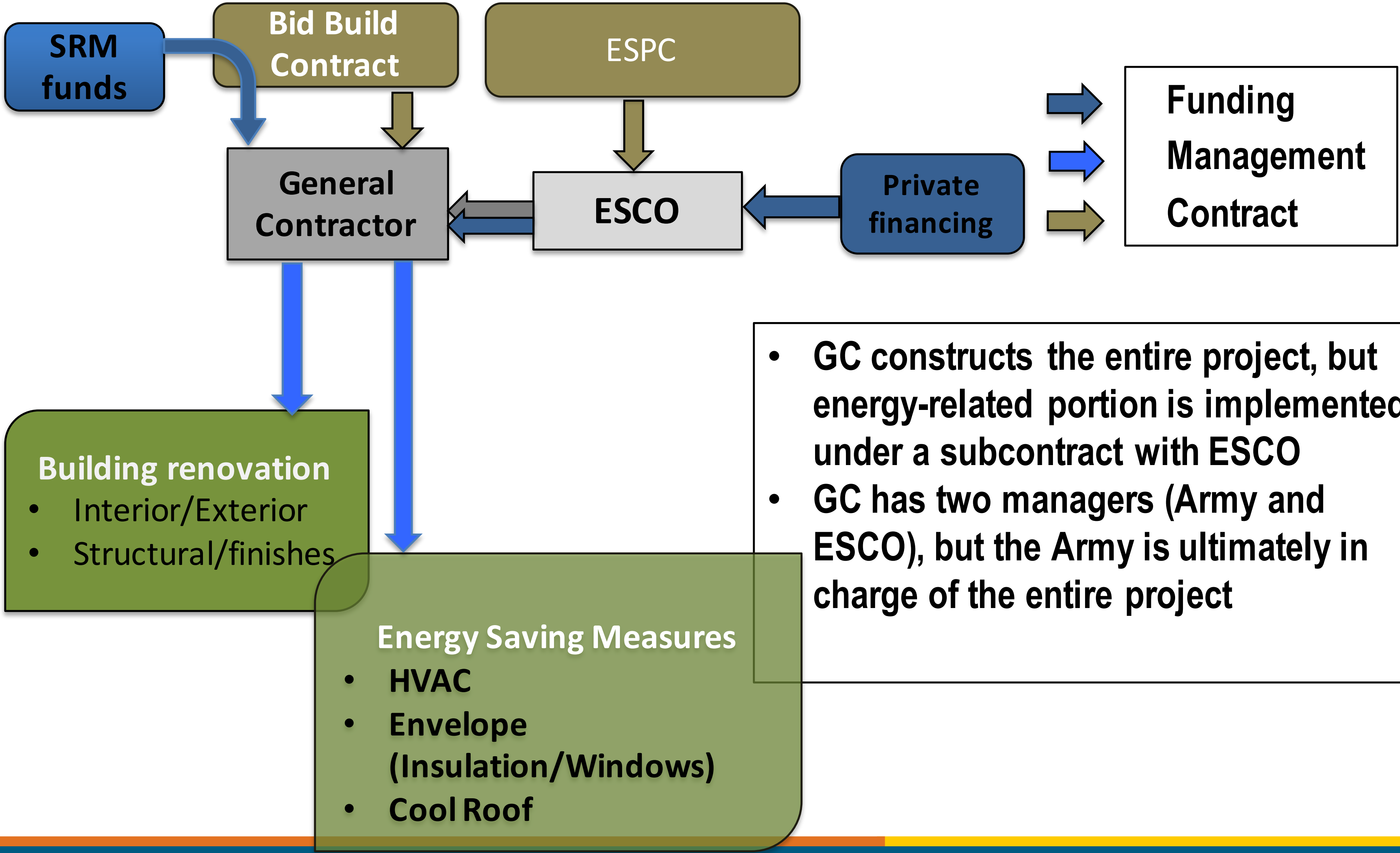
- The difference between DER cost and a standard renovation (BAU) cost = “delta cost” or a “premium cost” can be paid either from the same source as SRM project (if funds are available!) or using private party financing.
- When public funding is limited, public funds can be combined with private funds
- The optimal model will depend on legislative framework and contracting methods available, e.g.,
  - Energy Savings Performance Contract (ESPC)
  - Utility Energy Service Contract (UESC),
  - Enhanced Use Lease …
- The total scope (energy and non-energy related) of state and city owned renovation projects as well as all renovation projects in Europe can be executed using one contractor.
- Combining public (SRM) funds with private funds (ESCO) for Federal government projects in the USA requires a method of integrating the performance of a general contractor (performing renovations) and an ESCO (installing energy efficiency measures)

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

SRM-ESPC Deep Retrofit Project Model #2



- GC constructs the entire project, but energy-related portion is implemented under a subcontract with ESCO
- GC has two managers (Army and ESCO), but the Army is ultimately in charge of the entire project

Optimization of “Delta Cost”

- DER doesn’t require “bleeding edge” technologies
- Use of proven **core technologies bundles** can contribute to the most of DER energy use reduction and:
  - reduces project development time and cost,
  - provides a solid base for building energy use performance expectations resulting in lower cost of money from financiers ;
- Advanced QA starting with development of RFP and bidding process, improves project’s energy performance and results in reduced risks to the customer and contractor and therefore reduces construction cost;
- “Anyway” or BAU project costs (SRM part of the budget) typically covers most of contractor's out-of-pocket expenses for DER project which reduces risks and associated costs to the customer
- Significant building energy use reduction allows for additional subsidies and incentives (e.g., tax credits, grants, rebates, subsidized lending, etc)

Improving the Bottom Line

- DER projects result in a significant reduction of energy use and cost (>35% compared to BAU)
- Reduced thermal loads reduce HVAC system's size and complexity resulting in reduced O&M costs (per RMI, high performance buildings have 9-14% smaller maintenance costs compared to BAU baseline);
- Many DER projects result in adding rentable/usable space, e.g., due reduced size of mechanical rooms, adding thermally controlled areas (mansards, basements, repurposing storage spaces, etc.)
- DER resulting in a lower energy and sustainable building, accelerates lease-up time Vs. average market downtime and provide additional value due to a premium in rent over the top of the market rents
- Well planned and managed major renovation project combined with DER results in reduced NPV of the DER scenario Vs. standard renovation over the legal project life.

Advanced LCC – Maintenance and service life period

Maintenance Cost approaches:

- Usually the % of new investment costs, assuming a constant average value over service life period or a cost per area of the building area
- Different National standards and Guidance for service life period exist in EU and US
- Maintenance costs are available for individual equipment (LCC) and for bundles of technologies (quick estimate)
- ASHRAE XP 20 Database: for all building types mean maintenance cost is $0.34/ft2

Selected Equipment /System	VDI 2067/B 1 (DE) % of Investment costs
Boiler/Furnace	2%
Air Handling Unit (without distribution system)	3%
Cooling (water cooled chillers)	3%
Control (hybrid)	4%
District heating pipes	0,5%
Thermal Envelope	0,25-0,5%

Advanced LCC- Insurance Cost

Insurance Cost Reduction

- In DER projects typically larger parts of the technical installation and infrastructure is replaced. Insurance companies reduce premiums and pricing discounts to qualified and assessed DER projects (1) With ++ (5-10%), + (0-5%), - (no discount)
- With total costs of 4- 8 €/m² for pre- refurbished buildings cost saving potential has been achieved up to 3-4 €/m²

DER measure	Insurance risk				
	Fire&Wind Damage	Ice & Water Damage	Pipe Insurance	Boiler and Mech. Syst. insurance	Power Failures
Windows	++	++			
Thermal envelope					
Duct and pipe systems	++	+	++	+	
Electrical system				+	++
HVAC	++	+	++	++	+

Maximum Cost Effective Budget Increase for DER

ΔC = NPV *ΔFirst Cost ($) + NPV *ΔMaintenance ($) + + NPV *Replacement ($) + NPV *Δ Energy ($).

$$NPV = \frac{(1+i)^N - 1}{i \cdot (1+i)^N}$$

NPV = Net Present Value function
N = study life in years
i = interest or discount rate

$$\Delta \text{First Cost}_{\text{budget}} = SR_{\text{energy}} \cdot (\Delta \text{Energy Cost}_{\text{annual}}) + SR_{\text{maint}} \cdot (\Delta \text{Maintenance})$$

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

	Economic Life (yrs)			5	10	15	20	25	30	35	40	45	50
	Interest	Discount	Escalation										
1	0%	0%	0%	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
2	6%	0%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
3	6%	0%	3%	4.6	8.7	12.4	15.9	19.2	22.5	25.8	29.2	32.8	36.6
4	6%	0%	6%	5.0	10.3	16.0	22.4	29.7	38.5	48.9	61.7	77.5	97.0
5	6%	2%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
6	6%	2%	3%	4.6	8.6	12.3	15.6	18.6	21.5	24.3	27.0	29.8	32.5
7	6%	2%	6%	5.0	10.2	15.6	21.5	28.0	35.4	43.7	53.3	64.5	77.7
8	6%	4%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
9	6%	4%	3%	4.6	8.6	12.1	15.3	18.1	20.6	23.0	25.1	27.1	29.0
10	6%	4%	6%	5.0	10.1	15.3	20.7	26.5	32.5	39.0	46.0	53.6	61.9
11	6%	6%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
12	6%	6%	3%	4.6	8.6	12.0	15.0	17.6	19.8	21.8	23.4	24.9	26.2
13	6%	6%	6%	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
14	6%	8%	0%	4.2	7.4	9.7	11.5	12.8	13.8	14.5	15.0	15.5	15.8
15	6%	8%	3%	4.6	8.5	11.9	14.7	17.1	19.1	20.7	22.1	23.2	24.1
16	6%	8%	6%	5.0	9.9	14.7	19.3	23.7	27.8	31.7	35.2	38.5	41.5

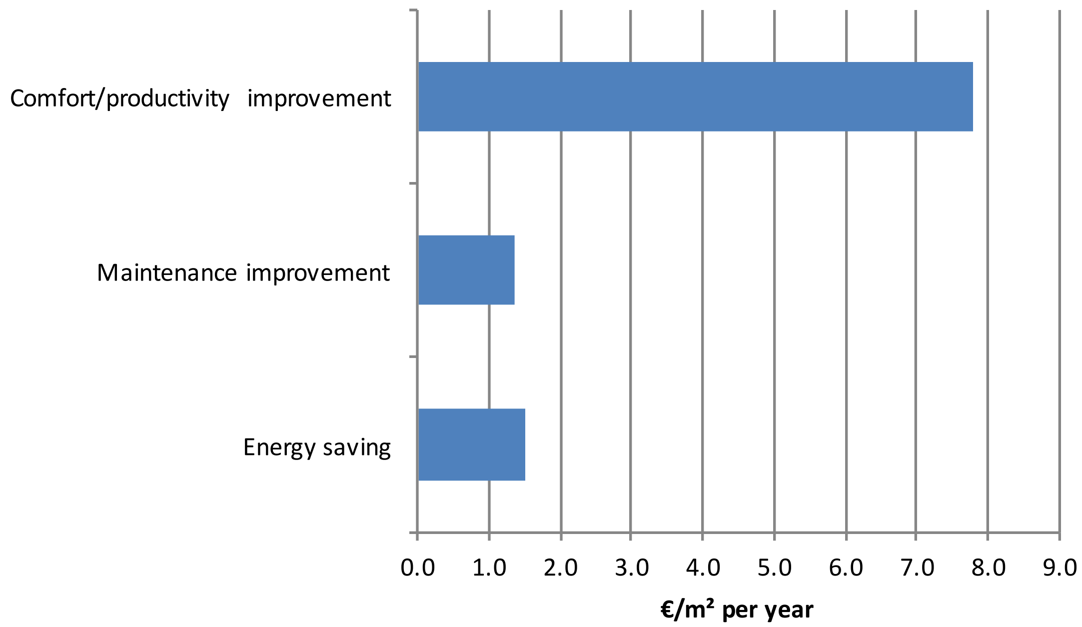
Bankable Value

- Retrofit development cost
- Energy related operating costs
- Retrofit risk mitigation
- Decreased company and property non-energy operating costs (maintenance costs ~ first cost of mechanical and energy conversion equipment),

Not Bankable Value

- Improved thermal comfort and IAQ, reduced absenteeism, increased productivity and reduced churn rate (internally or externally)
- Residual value of replaced building components (building insulation, windows, mechanical system components) due to their longer life compared to the project life.

However – Belgian experience



Factor4 data on net cost savings in an EPC-project (€/m² office per year)
www.comfortmeter.eu

Latvian residential ESCO model

- Renesco has 100% financed and performed deep renovations of 15 typical Soviet-era apartment buildings using EPC's. Bank provides **60% co-financing solely based on the EPC**, no other collateral. Apartment owners have not, and will not, pay anything, nor assume any risks.
- All investments are covered by future energy savings (20 years) and support from national renovation program (ERDF).
- Measures: full building envelope, new hot water networks, new heating network, new ventilation recovery systems, cosmetic repairs, switching to renewables (geo-thermal).





Before...   and after

Before... and after

Staircase and entrance repair

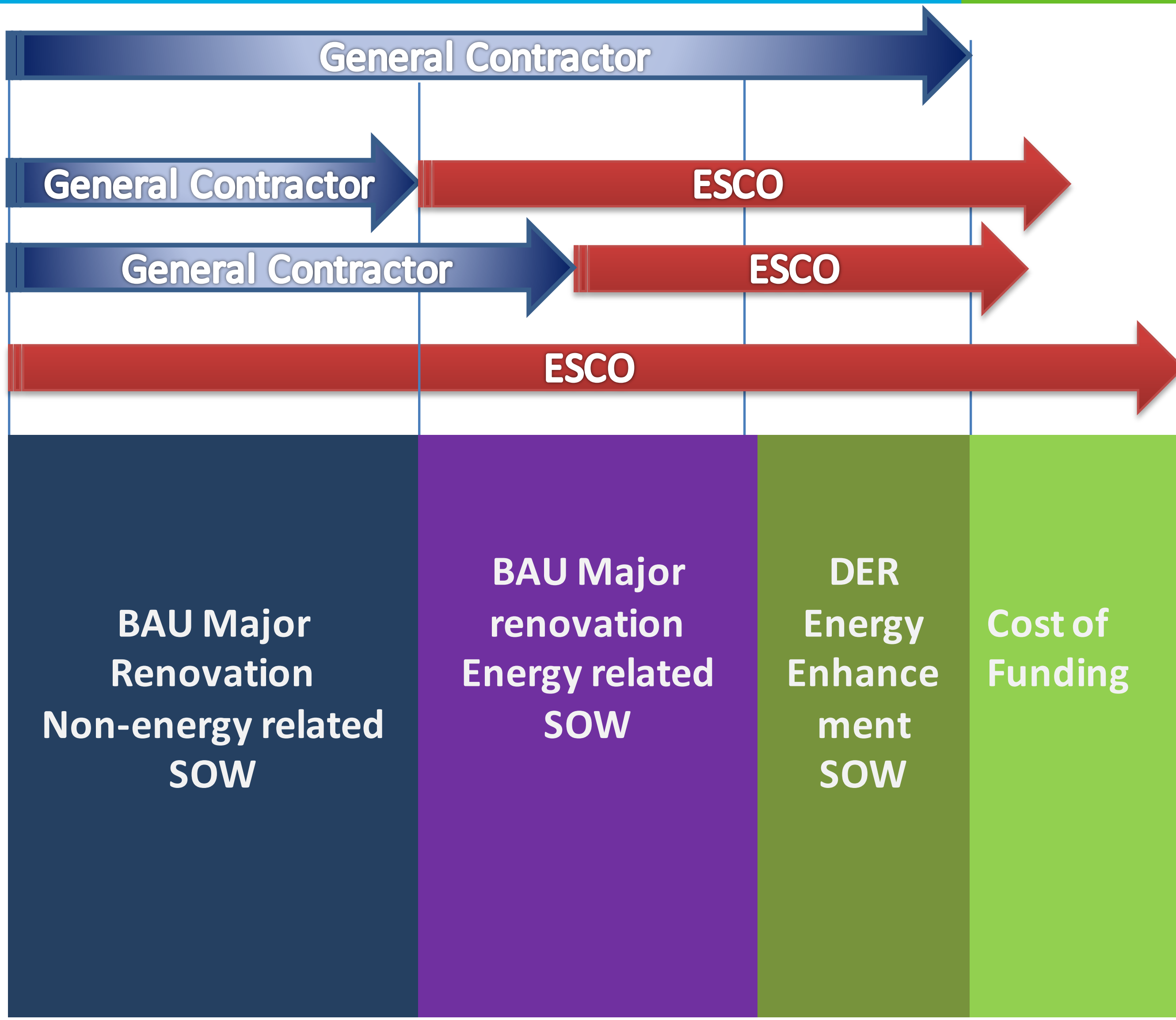
Windows and Doors

Case Study Economics for German Office Building

Pre-renovation EUI_{heat} = 224 kWh/m²yr ; $EUI_{electricity}$ = 62 kWh/m²yr

Scenario	1:"base case" minimum requirements	2: new building adopted to building stock	3: - 50%	4: Passive House
site energy savings	34%	60%	54%	70%
a)Heating energy savings	33%	68%	60%	83%
b) Energy related investment (€/m²)	200- 230	300- 330	280- 310	380- 430
c) delta energy related investment costs in comparison to scenario 1	-	100- 110	80- 100	180- 200
d)delta cost savings in comparison to scenario 1, €/m²yr	-	10	7- 10	10- 14
c/d (yrs)	-	10	10-11	14-18

DER Implementation Strategies



Major Barriers for Combining Public and Private Funding for Federal Government Projects

- Until recently, by legislation only energy conservation measures can be installed in a federal ESPC project. This means that a separate contractor in addition to the ESCO is required to perform tasks unrelated to building energy use, such as replacement of foundations and structural members, and replacement of tile and carpeting.
- Coordinating contract award, design and construction of two closely-related projects being performed by separate contractors under separate contracts – and separate contracting structures – creates legal, procurement and logistical issues that have yet to be fully resolved.

Questions, comments??